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THE SINUS MAXILLARIS AND ITS RELATIONS IN THE EMBRYO, CHILD, AND ADULT MAN.*

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This paper is based upon a study of the sinus maxillaris in the embryo in successive stages up to the fetus at term, as well as in the child and adult man. Most of the adult specimens ranged in age from 18 to 80 years.

The lateral nasal wall of the embryo, at different stages of growth, was modeled; thus showing the relations of the sinus maxillaris and its progress in development. The blotting-paper method was used in all the reconstructions. Both solid structures and cavities were modeled, thus securing positive and negative views.

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The work also covers a general consideration of the sinus in the child and the adult; including a study of the sinus relations, its ostium or aperture, and the ostium accessorium. Special attention was also given to the cause and effect of recesses occurring on the walls of the adult sinus. Dissections were made to cover all phases of the problem.

In determining the size of the sinus the following measurements were taken: (1) dorsosuperior diagonal; (2) ventrosuperior diagonal; (3) superoinferior; (4) ventrodorsal; (5) mediolateral.

The capacity of the sinus was determined by filling the cavity with a portion of a previously measured liquid, or by measuring the amount of water the hardened mucous membrane (representing the exact shape and size of the sinus) would displace.

I wish to take this opportunity for expressing grateful acknowledgment to the heads of the Departments of Anatomy, and Embryology and Histology for valuable criticisms and helpful suggestions. I also wish to express my grateful appreciation of the abundant material and other facilities placed at my disposal by the aforementioned departments. To Professor and Mrs. Gage, for the loan of embryos from the research collection, I wish to express thanks.

THE EMBRYOLOGY AND EARLY RELATIONS OF THE SINUS MAXILLARIS.

About the tenth week of fetal life the mucous membrane in the primitive middle meatus of the nose begins to pouch laterally. This pouch represents the Anlage of the sinus maxillaris, which pushes from the originally simple furrow separating the maxillo-turbinal (later concha nasalis inferior) and the first ethmo-turbinal (later concha nasalis media).

In order to gain a clearer conception of the location and relations of this primary maxillary pouch, and to better interpret adult conditions, a brief consideration of the lateral nasal wall, of the embryo, is necessary.

During the second month of intrauterine life, before the cavum nasi and the cavum oris have become separate cavities, we find three swellings on the lateral wall of the nasal fossa (maxillo-turbinal, appearing first; ethmo-turbinal, appearing

next; naso-turbinal—extremely rudimentary in man, appearing later (Fig. 1). The maxillo-turbinal corresponds to the adult concha nasalis inferior. The naso-turbinal, which is termed by Peter and others, "der Agger nasi," and by Killian, in conjunction with the primitive processus uncinatus, "der erste Hauptmuschel," persists in the adult as the agger nasi. The ethmo-turbinal undergoes subdivision, and by this division, according to Killian, five ethmo-turbinal plates, defined by six grooves, are usually formed. E. Kallius says, "Dass alle diese 6 Furchen ausgebildet sind, ist selten." Zuckerkandl's investigations show that three ethmo-turbinal plates are the typical number. He says, "Drei Siebbeinmuscheln repräsentieren demnach die typische Faltungsweise des Siebbeines." According to the embryos studied for this paper, I find that the number of furrows and ethmoidal conchæ varies, but in the specimens examined, four plates are rather common. The ethmo-turbinal plates and the resultant furrows become reduced in number as development goes on, and finally represent the chonchæ nasales, media and superior, and the meatus nasi, medius and superior, respectively. The reduction in number may not be carried so far, and this accounts for the supernumerary ethmoidal conchæ and meatus in many adults.

Just how the primitive nasal processes and furrows are formed is interpreted differently. Some claim that the projections are due to an inpushing of the lateral nasal wall by the cartilaginous strands which become the nasal conchæ. This latter claim I have been unable to verify, because I find that the folds or projections are invariably present before cartilage is found in them (Fig. 1). The elevations at first consist of a duplication of the ectoderm with indifferent mesenchyma, which, in part, later changes into cartilage. The nasal conchal cartilages are, therefore, a result and not a cause of the early condition. Schönemann claims that they are elevations left by excavations of furrows on the lateral wall of the nasal fossa. Killian and Mihalkovics hold that the projections are free ingrowing folds on the lateral wall of the nasal fossa. Glas concludes a discussion on the nasal conchæ in rats thus:

"Die Bildungsmodus der Muscheln ist die Resultierende zweier Komponenten; (1) des Auswachsens in die Wandpartien einwachsender Epithelleisten (Fissuren). (2) des Vorwachsens bestimmter Wandpartien."

After a study of these early conditions I am led to believe that the primitive furrows are primarily the result of an outpushing or outgrowing of the mucous membrane on the lateral wall of the nasal fossa. The projections, by a thickening of the mucous membrane (especially true in the ethmo-turbinal region) (Fig. 1), and the deepening of the furrows, become rapidly prominent. At times the two processes, an outgrowth or outpushing and a thickening of the intervening mucous membrane and mesenchyme, seem to be at work simultaneously in forming the early projections and furrows. The theory that the furrows are primarily started as an outpushing or outgrowing of mucous membrane is entirely in accord with, apparently, similar processes taking place in the early embryo nose; namely, the pouching or outgrowing of the mucous membrane as the Anlagen of some of the sinus paranasales. That a similar process should cause the formation of primarily similar outgrowths seems plausible.

It is, however, not the province of this paper to speak in detail of the development of the early projections and furrows; suffice it to say that it is from the furrow separating the primitive conchæ nasales, inferior and media, that the maxillary pouch evaginates. It is, therefore, the primitive meatus nasi medius with its contained structures, and the naso- and first ethmo-turbinals that especially concern us in the development and relations of the primitive sinus maxillaris.

Killian terms the naso-turbinal and the subdivisions of the ethmo-turbinal, "Hauptmuscheln;" and the smaller projections appearing in the furrows between these "Hauptmuscheln," as "Nebenmuscheln." What he terms "die zweite Hauptmuschel" will be spoken of in this paper as the concha nasalis media (first ethmoidal concha).

The naso-turbinal plus the processus uncinatus and the concha nasalis media have marked bends, thus presenting ascending and descending crura. Correspondingly the furrow between these conchæ has a bend, and presents ascending and descending limbs. For the sake of description we will consider the processus uncinatus as the descending crus of the naso-turbinal. The primitive meatus nasi medius has, therefore, as inferior boundaries the crura of the naso-turbinal and the space existing between the conchæ nasales, media and inferior. The superior boundaries of the space are the crura

of the concha nasalis media (zweite Hauptmuschel of Killian) (Fig. 4). To say then, as has been done earlier in this paper, that the maxillary pouch evaginates from the space separating the primitive conchæ nasales, inferior and media, is not giving the pouch its definite location.[1] The actual point of this primary pouching is from the primitive infundibulum ethmoidale, or the "unterer Recessus des absteigenden Astes der ersten Hauptfurche" of Killian.

This pouch is a minute epithelial sac, and forms the Anlage of the sinus maxillaris. Its earliest establishment precedes the appearance of the cartilage which later surrounds it. This is in accord with the statement of E. Kallius, that:

" * * * die Nebenhöhlen der Nase schon angelegt sind, ehe der Knorpel entsteht, und dass also das Skelett sich erst sekundär um jene herumlegt."

According to my observations the earliest evidences of maxillary pouching are found about the seventieth day of fetal life. Kallius places the time of the primary evagination during the middle of the third month, "Die Oberkieferhöhle erscheint in der Mitte des 3. Monats." J. Kollman places the time of pouching later, "Seine Anlage beginnt erst bei Foeten Von 8 cm. Länge." Gegenbaur quotes Dursy as authority for the following:

"Schon bei 8 cm. lange Embryonen buchtet sich der Raum der Nasenhöhle zwischen mittlerer und unterer Muschel gegen den hier verdickten Knorpel der Seitenwand der Nasenhöhle aus und bildet die Anlage des Sinus Maxillaris."

I have found the primitive maxillary pouch duplicated, i. e., two pouches growing laterally side by side. (This may explain some of the duplications of the adult ostium maxillare —the two primary pouches fusing distally, leaving the two points of evagination as the ostia maxillaria of the adult sinus. Other duplications of the adult ostium may be caused in a manner similar to the formation of the accessory ostium.)

This embryonal condition probably explains some of the cases in which the sinus maxillaris is divided into two partially or wholly separate compartments by a vertical partition, i. e.,

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[1]The relation of the space existing between the conchae nasales, inferior and media, to the descending ramus or limb of the first furrow is spoken of thus by Killian, "Der Raum zwischen zweiter Hauptmuschel und unterer Muschel ist demnach nur eine Art Vorhof zum absteigenden Theil der ersten Haupfurche."

each pouch developing into an adult cavity independent of its mate. (See subsequent paragraph.)

The primary ostium maxillare varies greatly in its dimensions in different embryos (Figs. 2, 3). This is entirely in accord with adult conditions, since the ostium of the adult sinus has a great range of dimensions (Table D). The great differences in the dimensions of the ostium may be due to early fusion of two or more primary maxillary pouches; or the primitive pouching may have been single, but extensive, as is frequently the case. These two latter would give rise to long slit-like ostia, while the single and less extensive pouching would give us the typically shaped and average sized adult ostium.

Some time prior to the establishment of the maxillary pouch[2] a ridge appears immediatelly inferior to the point of maxillary evagination. This ridge is the Anlage of the processus uncinatus and, as said before, will be considered, merely for the sake of description, as the descending crus of the nasoturbinal. It will be recalled that Killian terms the latter two structures, "die erste Hauptmuschel." This ridge has its free border directed superiorly, and it extends in a ventrosuperior direction. It early tends to form a shallow groove immediately superior to it, which is the primitive infundibulum ethmoidale (Recessus inferior des absteigenden Astes der ersten Hauptfurche of Killian). To be accurate, then, we must say that the maxillary pouch evaginates from the primitive infundibulum ethmoidale—a part of the meatus nasi medius.

Some time after the appearance of these structures there is a more or less uneven bulging on the lateral wall of the primitive meatus nasi medius, immediately superior and lateral to the free border of the processus uncinatus (Fig. 4). This is the Anlage of the bulla ethmoidalis. The slit-like space existing between the free border of the processus uncinatus and the bulla ethmoidalis is the primary hiatus semilunaris. Through this slit the infundibulum ethmoidale communicates

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[2]It is indeed difficult, in some cases, to say which structure is the primary one in establishing an Anlage. In most cases the processus uncinatus is the first to appear, and in some instances it is impossible to say whether the pouching of the mucous membrane, or the formation of the ridge is first. It may, however, be said that both structures are more or less dependent upon each other in establishing Anlagen.

directly, and the primitive sinus maxillaris indirectly, with the meatus nasi medius.

Killian subdivides the uneven thickening on the lateral wall of his "Ramus decendens der ersten Hauptfurche" into small projections with very shallow intervening furrows. The projections are his "absteigende Nebenmuscheln," and the furrows the "obere und untere Zwischenfurchen" of the first furrow, or the primitive meatus nasi medius. He concludes that the bulla is formed by the early fusion of some of the processes (Nebenmuscheln). The space immediately inferior to his "untere Nebenmuscheln," or the space he designates as the "Recessus inferior" of his first chief furrow, is the infundibulum ethmoidale—the exact place of the primary maxillary pouching.

At this juncture mention must be made of the primary pouching of the sinus frontalis in order to interpret later conditions in connection with adult frontomaxillary relations. It will be remembered that the furrow from which the maxillary pouch evaginates has ascending and descending rami, and that from the descending ramus the maxillary evagination takes place. The ascending ramus of this furrow widens and pushes ventrally and superiorly. Turner says:

"It is generally held that the frontal sinus commences to develop at the end of the first or the beginning of the second year of life, as an upward expansion of the ethmoid cell labyrinth."

Hartman quotes Steiner for the following:

"Der erste Anlage der Stirnhöhle ist in der Anlage des knorpeligen Siebbeinlabyrinthes gegeben. Mit der Entwickelung der zelligen Räume des vorderen Siebbeinlabyrinthes beginnt auch die der Stirnhöhle, denn letztere stellt eben nur die Ausdehnung der vorderen Siebbeinzellen nach oben dar."

Hartman makes the following statement:

"Aus dem aufsteigenden Ast der ersten Hauptfurche bildet sich durch oberflachliche Verwachsung eine sackartige Bucht, der Recessus ascendens od. R. frontalis, die Stirnbucht. Aus der Stirnbucht entwickelt sich die Stirnhöhle."

The embryos studied showed evidence of a slight pouching at the superior and ventral end of the primitive meatus nasi medius. This doubtless corresponds to the "Recessus frontalis" of the first chief furrow of Hartman and Killian.

According to Killian's commendable work there are three processes and four furrows on the lateral wall of the recessus frontalis, which are designated by him as "Stirnmuscheln und Stirnfurchen," respectively. The furrows, according to Killian, form the Anlagen of the cellulæ ethmoidales anterior, or cellulæ frontales, as some call them. From this he concludes that the sinus frontalis may continue its development in one of the following ways: (1) by extension of the frontal recess (direct method), (2) by extension of a frontal cell (indirect method), (3) by extension of the frontal recess and a frontal cell, (4) by extension of two frontal cells. With these facts kept in mind—allowing for further differentiation during development—it is easier to understand why the sinus frontalis, in the adult, connects either with the infundibulum ethmoidale, with the meatus nasi medius, or with both. These embryologic facts are of importance in connection with adult frontomaxillary relations. Doubtless more work should be done on the development of the nasofrontal duct in order to clear up some points in connection with the relations existing between the sinus frontalis and maxillaris. I am now working along this line and hope to report my findings at some future time.

Although the pouching to form the recessus frontalis, or what may be termed the Anlage of the sinus frontalis, begins during the third month of fetal life, as does that of the sinus maxillaris, the extension of the sinus frontalis is for a time so small that it is usually regarded as wanting at birth. This is in part due to the fact that the sinus frontalis is as a rule looked for in the frontal or vertical portion of the frontal bone, while the first evidences of it are to be sought elsewhere. In fact, according to Lothrop's investigations, the sinus frontalis of the adult does not reach the vertical or frontal portion of the frontal bone in about three per cent of cases—the only evidences of the sinus appearing in the horizontal or orbital portion of the frontal bone. It must, however, be said that the sinus frontalis is tardy in its development until after birth; while, on the other hand, the pouch forming the Anlage of the sinus maxillaris develops more rapidly and occupies a definite space in the lateral wall of the nasal fossa by the end of the third fetal month (Figs. 2, 3).

By the simultaneous processes of resorption of surrounding tissue and the growth of the maxillary pouch, the primitive

cavity gains more and more capacity. The pouch soon acquires a slit-like shape at the side of the nose (Fig. 4). It has its greatest measurement in the ventrodorsal direction, while mediolaterally the cavity occupies comparatively little space. In embryos aged from 100 to 105 days the ventrodorsal measurement is about 2 mm. (Fig. 2). In a 120-day embryo the distance is about 2.5 mm. (Figs. 3 and 5A). In a 100-day embryo the most ventral spur of the sinus is about 6.5 mm., and the most dorsal spur 8.5 mm. from the tip of the nose.

It will be remembered that, in the embryo, the processus alveolaris of the maxilla is in proximity to the orbit, and when we recall the fact that the unerupted teeth are contained in this situation, it at once becomes evident that the sinus maxillaris must be correspondingly small at this time. Because of these facts the sinus of a 7-month fetus measures only 5 mm. in the ventrodorsal plane, while that of a fetus at term has increased this distance to approximately 7 mm. (Fig. 5B). During the latter month of intrauterine life the sinus gains in the mediolateral plane, so that at term this distance measures from 3 to 4 mm.

It is generally stated that the deciduous teeth hold the sinus maxillaris in check, and that the cavity rapidly assumes larger dimensions as the first dentition progresses. I, however, find that the growth of the sinus is rather uniform, and that the first dentition has little to do with any rapid increase in the size of the cavity. The age of the child and the size of the sinus, apparently, progress pari passu (Fig. 6).

The ventrodorsal measurement of the sinus in a child aged 6 months is 10 mm., but the cavity has not developed sufficiently in the mediolateral plane to reach beneath the orbit. In a child of 9 months the ventrodorsal distance is 14 mm., with a superoinferior measurement of 5 mm. At the end of the first year the sinus has reached a ventrodorsal measurement of 16 mm., a superoinferior of 6 mm.; and has now reached a mediolateral point sufficient to pass beneath the orbit. As the maxilla grows, the sinus remains for some time on the medial side of the infraorbital canal (Fig. 10). By the twentieth month the sinus measures ventrodorsally 20 mm. (Fig. 5) and has, as a rule, extended above the rudimentary first permanent molar tooth.

Before and during dentition the sinus maxillaris is sepa-

rated from the front of the maxilla by the unerupted teeth (Fig. 17). After the eruption of the deciduous teeth the cavity continues to have a more or less rounded and elongated shape (Fig. 5D). It is really never spherical, as is often stated, but has an irregular elongated form from the beginning.

After the eruption of the permanent teeth the sinus begins to lose its rounded and elongated shape and to assume the adult pyramidal form (Figs. 7, 8 and 9). By the twelfth or fifteenth year of age, when the second molar has appeared, the sinus approaches, though it has not yet attained its definite shape. The sinus reaches its full size between the fourteenth and eighteenth year.

THE ADULT SINUS MAXILLARIS.

The adult sinus maxillaris was known to Galenus (130-201), but apparently Dr. Nathaniel Highmore was the first to give any detailed description of it. In his work (1651), "Corporis Humani Disquisitio Anatomica," he describes the cavity in the maxilla, to which his attention was drawn by a lady patient, in whom an abscess of this cavity, since known as the antrum of Highmore (sinus maxillaris), was drained by the extraction of the canine tooth (left). The following are the exact words of Dr. Highmore in describing the cavity located in the body of the maxilla. His report of the case also follows:

"ANTRUM MAXILLAE SUPERIORSIS."

"Antrum hoc utrinque unum, sub oculi sede inferiore ubi os ad ocul tutelam quodammodo protuberat, ad latera inferiora nasi situm est. Insigniter cavum sphaericum, aliquantulum vero oblongum, et ita amplum ut articulus pollicus majoris pedis ultimus in illo delitescat, * * * Osse attenuata seu squammâ osseâ obtegitur: Os enim quod illud includit, et quod a dentium alveolis extremis distinguit, crassitie chartam Emporeticam non multum excedit. * * * In basi hujus protuberantis quaedam eminentiae cernuntur. * * * Quibus dentium apices tenniores includuntur. * * * Dentium alveoli margini hujus ossis inferiori insculpuntur, quibus dentes infiguntur. * * * Antrum hoc frequentius vacuum, aliquando muco repletum reperitur, in quod humores a capite per

meatum quendam a cavitate illa in osse frontis, et ab osse ethmoeide destillare poterunt. * * *

"Atque hic silentio praeterire non possumus, quod generosae cuidam foeminae sub nostra cura laboranti accedit. Cum sub ferina eaque continua falsi humoris distillatione, per multos retro annos laborasset, omnesque pené dentes corrosos ac cariosos evulserat; nec tamen a dolore liberata, tandem dente canino sinistri lateris effosso * * * Simul squammosa illa distinctio inter cavitatem hanc et dentis foveam eriptur, adeo ut humorum, per alveolum dicti dentis, ab antro illo perrenis successerit destillateo; Qua multum perterrita, stylo argenteo in alveolum immissa originem fontis hujus exploratura, usque ad oculum, per uncias pené duas sursum adegit; magis adhuc metuens, pennam minorem plumis decerptis totam pené ad longitudinem palmae unius immisit. Iam maximae consternata, ad Cerebrum usque decurrere existimans, me inter alias consulit; ubi autem singulas examinavimus circumstantias, pennae reduplicationes, illamque per cavitatem hanc circumgyrare invenimus. Atque sic, ubi in figura seguenti cavitatem hanc designavimus, illam de usu ac necessitate hujus satis instructam, perennisque illius fontis patentissimam habuimus, a timore et medicina simul desistit.

"Antrum hoc levitatis ossium causa, quae hic oculorum situs gratia crassa esse debuere, factum esse arbitramur."

The antrum (sinus maxillaris) described by Highmore must have been an exceptionally large one, because the canine tooth does not as a rule come in relation with the sinus. This same tooth is mentioned by some writers even to-day as the tooth to extract in draining the sinus. It is a very bad tooth to select for this purpose in the great majority of cases. This fact will be referred to in a subsequent paragraph when considering teeth relations. It will also be noticed that Highmore had a somewhat faulty idea of the shape of the adult cavity. He, however, mentions some very essential conditions in his descriptions of the adult sinus. His consideration of the cavity is very brief and many important factors are omitted. His report of the case through which his attention was called to this cavity, is unique and interesting.

The adult sinus maxillaris, as we know it, is the large cavity within the body of the maxilla. It is the largest of the

sinus paranasales, save in exceptional cases, when it is comparatively small and may be exceeded in size by the sinus frontalis and the sinus sphenoidalis. It lies lateral to the cavum nasi and resembles in shape a three sided pyramid (Fig. 7). It follows in the main the shape of the body of the maxilla; and may be described as having a roof, a floor and three walls. The walls of the sinus vary in thickness, usually from 5 to 8 mm.; but they may be reduced to a papery delicacy. The base or median wall is directed toward the cavum nasi, and the apex of the sinus extends into the root of the processus zygomaticus of the maxilla. It may even extend into the maxillary border of the zygomatic bone; thus extending the recessus zygomaticus of the sinus maxillaris.

The ventral wall of the cavity corresponds to the anterior or facial surface of the maxilla, and looks ventrolaterally. Part of this wall is at times greatly approximated to the dorsal wall and base of the sinus, due to a very prominent fossa canina. Occasionally the whole ventral wall bulges markedly into the cavity of the sinus

The dorsal wall of the sinus corresponds to the infratemporal surface of the maxilla. It is a thin plate of bone, also forming the ventral boundary of the infratemporal and the pterygopalatine fossæ. This wall is usually the thickest of the sinus walls—it is, however, occasionally extremely thin (the processus alveolaris being recognized as the floor of the cavity and not as a wall).

The base or median wall is directed towards the cavum nasi. It presents a very irregular orifice—hiatus maxillaris, in the disarticulated bone. In the articulated skull this opening is partly filled in by the pars perpendicularis of the palate bone, the processus uncinatus of the ethmoid bone, the processus maxillaris of the inferior nasal concha, and a portion of the lacrimal bone. In the undissected state this irregular aperture formed by these bones is rounded by mucous membrane, which is continued into the sinus maxillaris from the cavum nasi. This rounded opening—ostium maxillare, may be duplicated; and such duplication must not be confused with the ostium maxillare accessorium, which is a direst passageway between the sinus and the cavum nasi. The ostium or ostia maxillaria establish a communication between the sinus and the infundibulum ethmoidale. The medial wall immedi-

ately inferior to the attachment of the concha nasalis inferior is very thin and is easily punctured in this region. This wail also forms the lateral boundary of the cavum nasi and often markedly encroaches upon the cavity of the sinus maxillaris, which greatly influences its size.

The roof of the sinus maxillaris is a very thin plate of bone, at times of a papery delicacy. It also forms the floor of the orbit and the orbital surface of the maxilla. It is often modeled by a ridge formed by the infraorbital canal. In some cases the ridge is replaced by a groove which is covered over with the mucous membrane of the cavity. At times the roof of the sinus is partially divided into two plates separated by air cells. Occasionally the palate bone aids in forming the roof.

The floor of the sinus is formed by the processus alveolaris of the maxilla. It is by far the thickest of the osseous boundaries of the cavity—the thickness of the floor depending upon the degree of hollowing out of the process. In cases where the hollowing out has been carried far, the floor of the sinus will bear an important relation to some of the teeth and their sockets. The floor of the sinus may be thrown into irregular elevations by the fangs of the teeth—this depending upon the thickness of the layer of spongy bone. This layer varies in thickness in different skulls, and there may be considerable asymmetry on the two sides of the same skull. The relation of the teeth will be considered in a subsequent paragraph.

THE RELATION OF THE SINUS FLOOR TO THE NASAL FLOOR.

The relation of the floor of the sinus maxillaris to the floor of the nose depends largely upon the degree of hollowing out of the processus alveolaris of the maxilla. The degree of arching of the palatum durum—thereby affecting the floor of the nose, has also some bearing on this relation. When the layer of spongy bone is thin, i. e., the processus alveolaris of the maxilla markedly hollowed out, the floor of the sinus is at a level inferior to the nasal floor. On the other hand, when the processus alveolaris is comparatively thick, the floor of the nose is inferior to the sinus floor. Occasionally both floors are in the same plane (Figs. 8, 9 and 11). When the anterior surface of the maxilla and the lateral wall of the nose are

markedly bulging toward the sinus maxillaris, the floor of the nose is, as a rule, inferior to the floor of the sinus. It, however, remains that the majority of sinuses have their floors, at varying distances, inferior to the floor of the nose. Sixty adult specimens were examined to ascertain this relation, with results as appended:

Number examined	Sinus floor inferior	Nose floor inferior	Same level
60	39	12	9

The difference in levels of these two floors, when not in the same plane, varies from one-half to 10 mm. C. Resschreiter says that it is a male characteristic to find the sinus floor at an inferior level to the nasal floor. I have, however, been unable to verify this statement, and give the following as typical of my findings:

Number examined	Sinus floor inferior	Nose floor inferior	Same level
12 (female)	9	2	1

RELATION OF THE SINUS MAXILLARIS TO THE TEETH.

Since the sinus maxillaris varies greatly in size in different skulls, and on the two sides of the same skull, it at once becomes apparent that the relations of the teeth to the sinus cannot be constant. As stated before, the layer of spongy bone between the roots of the teeth and the floor of the sinus varies in thickness in different skulls, and the asymmetry on the two sides of the same skull is at times marked. When this layer of spongy bone is comparatively thin the projecting tooth fangs form elevations, of a greater or less degree, on the floor of the sinus. These elevations at times aid in recess formation (Fig. 16). Direct communication between the fangs of the teeth and the mucous membrane of the sinus, due to extreme hollowing out of the processus alveolaris of the maxilla, occurs most frequently in the aged (Fig. 15). This latter condition does, however, occasionally prevail in the young adult (Fig. 16). That very intimate relations frequently exist between the teeth and the sinus maxillaris is a fact that we should be cognizant of, but I find that these intimate relations have been somewhat exaggerated by some writers.

The number of teeth that bear a direct relation to the sinus is necessarily inconstant, as stated before. In exceptional cases, when the cavity is very large—especially in the line of the ventrosuperior diagonal, all of the teeth of the true maxilla may be in relation with the sinus (Fig. 15). It is, however, only an occasional occurrence to have the canine in direct relation with the sinus. In a certain number of cases the first premolar tooth bears a direct relation to the cavity, and in a slightly larger percentage of cases the second premolar bears a similar relation. The three most constant teeth, however, in direct relation to the sinus are the three molars. When the sinus maxillaris is small the first molar must be omitted from the direct relation (Figs. 12 to 16).

It is a fairly safe rule to follow, that, when the canine fossa and the lateral nasal wall are simultaneously approximated, the canine and premolar teeth do not bear a direct relation to the sinus maxillaris. In such cases a perforator pushed through a premolar tooth socket might readily enter the lateral nasal wall—even pass through it, passing entirely free of the sinus cavity. Again, if the perforator were pushed through the lateral nasal wall, inferior to the concha nasalis inferior, the instrument could readily be pushed through the soft structures of the cheek, unless the point were directed well superodorsally.

RIDGES, CRESCENTIC PROJECTIONS, AND SEPTA ON THE SINUS WALLS.

It is important to note how frequently the walls of the sinus are found uneven. These irregularities may consist of mere ridges or of different sized crescentic projections. The crescentic projections have been reported occasionally replaced by septa which completely divide the sinus into two cavities, each having its independent opening into the nasal fossa, but not communicating with each other (Fig. 22). The smaller ridges are of little consequence and may be omitted from further consideration. The larger ridges and crescentic projections, on the other hand, tend to form pockets and recesses, of varying depths, within the cavity. The septa, when they exist, may be placed either superoinferiorly or ventrodorsally; thus forming either ventral and dorsal, or

inferior and superior compartments, respectively. According to Zuckerkandl's findings, the superior and dorsal cavities communicate with the meatus nasi superior, and the ventral and inferior cavities with the infundibulum ethmoidale. Bruhl found the inferior compartment communicating with the meatus nasi inferior. Gruber found a complete division of the sinus maxillaris in 2.5 per cent of cases.

In the material used for this paper no sinus was found showing division into two distinctly separate compartments, but the specimens repeatedly showed crescentic projections and ridges which formed pockets of a greater or less depth (Figs. 18 to 23).

Sixty sinuses were examined to cover this phase of the work, with results as follows:

Number examined	Ridges or crescentic projections	Sinus walls even
60	29	31

It must be borne in mind that, in the 29 positive sinuses, quite a number of them showed mere ridges—the latter will be omitted from further study. The remaining number of the positive group fall, however, into a very important class of specimens. That these crescentic projections offer, at times, almost insuperable obstruction in attempting to drain fluid from the sinus through an opening either in the processus alveolaris, or in the meatus nasi inferior, is a fact that we should be cognizant of. This was repeatedly demonstrated by first filling the sinus with a liquid, then making an opening at some point on the processus alveolaris; thus draining out what would come away. If some of the fluid was retained—allowing for adherence to mucous membrane—the facial or anterior surface of the maxilla was removed to find where the remaining fluid was lodged. As a rule the portion of fluid was retained by a recess or recesses on one or more of the sinus walls. At other times a second and even a third opening was made, either through the alveolar border or through the meatus nasi inferior, before the remaining fluid would come away. If after repeated attempts the fluid could not be located, the ventral wall of the cavity was removed to ascertain the reason for its retention, and the fact was thus demonstrated that repeated punctures, in some cases, would not reach all of the recesses.

Just what these recesses mean in all cases is difficult to say. Some of them are, of course, formed by elevations caused by tooth fangs, but these, as a rule, are of minor importance and only occasionally form deep recesses. Others are formed by projections of mucous membrane, which may or may not be caused by crescentic bone projections. Where complete septa exist, the sinus maxillaris very likely developed from two primary pouches. In some cases the intervening wall may have disappeared in part, thus leaving the larger crescentic projections which occasionally are found in the adult sinus. A double pouching of the primitive sinus maxillaris was mentioned in a previous paragraph on the development of the cavity. Unequal resorption of the bone during the growth of the sinus is doubtless a cause for some projections occurring on the walls of the cavity.

THE SIZE OF THE SINUS MAXILLARIS.

The sinus maxillaris varies greatly in size in different individuals. There may also exist considerable asymmetry on the two sides of the same individual. The statement that all old people have large sinuses is very fallacious, as is also the statement that all females have smaller sinuses than males (tables A, B. C).

The investigations of Zuckerkandl have shown that enlargement of the sinus maxillaris may be produced by:

a. Hollowing out of the processus alveolaris of the maxilla (recessus alveolaris);

b. Excavation of the floor of the nasal fossa by a pushing of the recessus alveolaris between the plates of the palatum durum (recessus palatinus):

c. Extension of the sinus maxillaris into the processus frontalis of the maxilla (recessus infraorbitalis);

d. Hollowing out of the processus zygomaticus of the maxilla (recessus zygomaticus):

e. Extension to, and appropriation of an air cell within the processus orbitalis of the palate bone;

To these should be added, according to my findings:

f. Extreme hollowing out of the body of the maxilla in all directions, thus causing the sinus walls to be thin and the recesses all markedly developed;

g. The rarer condition when the lateral nasal wall is bulging towards the cavum nasi;

h. The extension of the recessus zygomaticus of the sinus maxillaris into the maxillary border of the zygomatic bone.

Zuckerkandl has found that the sinus may be made smaller, on the other hand, by:

a. Deficient absorption of the cancellated bone on the floor of the sinus;

b. Encroachment of the ventral wall of the cavity;

c. A deep fossa canina;

d. Thick sinus walls;

e. Excessive lateral bulging of the nasal wall;

f. A combination of the above conditions;

g. Imperfect dentition.

The thickness of the sinus walls varies from 5 to 8 mm. and down to that of a papery delicacy. The statement that all large cavities have thin walls and small cavities invariably thick walls does not hold in all cases. The smallest sinus measured in this series had the thinnest walls—of a papery delicacy. The smallness of this cavity was in part due to the marked simultaneous approximation of the ventral and medial walls.

The size of the sinus maxillaris is best determined by a series of measurements, viz.:

1. Dorsosuperior diagonal (D. S. D.)
2. Ventrosuperior diagonal (V. S. D.)
3. Superoinferior (S. I.)
4. Ventrodorsal (V. D.)
5. Mediolateral (M. L.)

These several measurements are determined thus (Fig. 24):

1. The dorsosuperior diagonal, from the most dorsal and lateral part of the sinus floor diagonally across the base or median wall of the sinus, to the most medial and superior part of the recessus infraorbitalis;

2. The ventrosuperior diagonal, from the most ventral and medial part of the recessus alveolaris diagonally across the base of the sinus, to the most lateral and superior point of the cavity;

3. The superoinferior, from the roof or infraorbital wall of the sinus, to the sinus floor (always using uniform points);

4. The ventrodorsal, from the most ventral point of the cavity midway between the roof and the floor, to the dorsal wall;

5. The mediolateral, from the base midway between its most ventral and dorsal points, to the processus zygomaticus of the maxilla (in some cases this extends into the maxillary border of the zygomatic bone, due to the extension of the recessus zygomaticus of the sinus maxillaris into this bone).

The ventrodorsal distance is especially affected by the degree of approximation of the ventral wall of the sinus; the superoinferior by the degree of hollowing out of the processus alveolaris of the maxilla; the mediolateral by the degree of encroachment of the lateral nasal wall; the ventrosuperior diagonal by the extent of the recessus alveolaris; and the dorsosuperior diagonal by the extent of the recessus infraorbitalis. Of course, there are other contributing factors to shorten or lengthen these distances, but these are the primary factors especially affecting the several measurements.

In order that the measurements of the sinus maxillaris may be of most value, it is necessary to compare the two sinuses of the same individual, to compare them with the respective sinuses of another individual; also to consider the age and the sex.

A careful examination of the following tables (A, B, C) will show conclusively that the sinus maxillaris has a rather wide range of variation. These tables also show that in the adult, age does not have much bearing on the size of the cavity. A reference to table C will show that the smallest cavity is that of an old man, aged 70 years; while the largest cavity is also that of an old man, aged 77 years. This same table shows that the cavity of a young adult, aged 21 years, is a close second to the largest sinus found in the whole series. Although the cavity in the male averages slightly larger than that of the female, a reference to table C will show that sex affects the size of the sinus but slightly.

The following may be given as average measurements of the adult sinus maxillaris, based on the measurements of 90 specimens:

		mm.
1	Dorsosuperior diagonal	38
2	Ventrosuperior diagonal	38.5
3	Superoinferior	33
4	Ventrodorsal	34
5	Mediolateral	23

Due to the great differences in the several measurements, the capacity of the sinus, in different individuals, must also differ. The range in capacity, of the sinuses studied to ascertain this fact, was from 9.5 cc. to 20 cc., with an average of 14.75 cc.

The tables A, B, and C show the range of measurements.

The conditions which produce these varied differences in the dimensions of the sinus maxillaris may be readily ascertained. Take for example the following two conditions which show a marked difference in the mediolateral plane, and yet the other measurements are inversed:

No.	V. D. mm.	M. L. mm.	S. I. mm.	D. S. D. mm.	V. S. D. mm.
1	30	18	40	41	41
2	35	35	35	40	30

In case No. 1 the lateral nasal wall was markedly bulging towards the sinus. In consequence of this encroachment, the mediolateral distance was greatly lessened. In case 2 the recessus alveolaris was poorly developed, hence the short ventrosuperior diagonal in comparison with the respective measurement in case No. 1. These cases show that even though a sinus may greatly exceed another in one of its measurements, it may be exceeded in size in its other planes.

Again there may be a great difference in the ventrodorsal distance. This means a marked inpushing of the ventral wall of the sinus, on the one hand, and a shallow fossa canina with a lessened encroachment on the other hand. Thus:

No.	V. D. mm.	M. L. mm.	S. I. mm.	D. S. D. mm.	V. S. D. mm.
1	25	15	25	35	36
2	43	20	30	41	37

If the body of the maxilla is hollowed out to a marked degree in all directions the measurements will be correspondingly lengthened. When this hollowing out has not been carried far, and when associated with some of the above mentioned conditions, the measurements will be markedly lessened. Thus:

No.	V. D. mm.	M. L. mm.	S. I. mm.	D. S. D. mm.	V. S. D, mm.
1	47	40	50	57	60
2	16	12	21	21	20

TABLE A.

Number	Sex	Age	Side	Ventro-Dorsal	Medio-Lateral	Supero-Inferior	Dorso-Superior Diagonal	Ventro-Superior Diagonal
				mm.	mm.	mm.	mm.	mm.
1	M	54	right	26	15	20	30	26
			left	30	16	22	32	26
2	M	68	right	40	22	50	50	50
			left	35	24	35	45	50
3	M	36	right	32	32	40	40	38
			left	30	18	40	41	41
4	M	65	right	30	15	30	33	30
			left	25	15	25	35	36
5	M	55	right	40	25	40	45	45
			left	40	22	38	36	45
6	M	57	right	40	21	32	50	38
			left	32	25	30	32	43
7	M	71	right	35	22	45	45	40
			left	40	18	35	40	45
8	M	59	right	40	22	33	45	45
			left	40	35	40	50	45
9	M	79	right	30	30	35	41	40
			left	43	20	30	41	37
10	M	55	right	31	24	30	30	38
			left	32	25	35	40	40

TABLE B.

Number	Sex	Age	Side	Ventro-Dorsal	Medio-Lateral	Supero-Inferior	Dorso-Superior Diagonal	Ventro-Superior Diagonal
				mm.	mm.	mm.	mm.	mm.
1	F	68	right	35	35	35	40	30
			left	40	16	30	43	36
2	F	52	right	35	21	30	40	40
			left	35	24	28	38	45
3	F	53	right	40	25	30	60	42
			left	33	30	45	45	46
4	F	47	right	36	26	25	37	37
			left	37	28	35	35	37
5	F	73	right	33	24	31	38	40
			left	37	24	37	30	42
6	F	50	right	33	17	30	35	40
			left	33	22	33	38	34
7	F	35	right	30	18	32	30	35
			left	30	21	30	30	40
8	F	39	right	34	25	33	32	35
			left	33	22	33	32	24
9	F	72	right	38	25	38	32	34
			left	35	23	38	33	35
10	F	52	right	35	21	30	40	36
			left	35	21	32	38	35

TABLE C.

Number	Sex	Age	Side	Ventro-Dorsal	Medio-Lateral	Supero-Inferior	Dorso-Superior Diagonal	Ventro-Superior Diagonal
				mm.	mm.	mm.	mm.	mm.
1	M	70	right	15	12	21	21	18
2	M	70	left	16	12	21	21	20
3	M	35	left	22	20	30	31	25
4	M	54	left	25	15	22	32	27
5	F	54	right	26	15	20	30	26
6	M	60	left	30	20	22	38	25
7	F	52	right	35	25	30	37	38
8	M	59	left	40	22	32	45	45
9	M	21	right	46	33	26	50	50
10	M	77	left	47	40	50	57	60

These few examples show how anatomic conditions will affect the measurements of the sinus maxillaris. It, therefore, appears reasonable that, by examination of the anterior surface of the maxilla and the lateral nasal wall, the size of the sinus may be approximately determined and the teeth relations judged. It does, however, not necessarily follow, because the ventral and median walls of the sinus are closely approximated, that the sinus capacity is markedly lessened. These sinuses may have marked infraorbital recesses and the processus alveolaris may be hollowed out towards its dorsal termination. In this manner compensation may be made for the marked bulging toward the cavity of the ventral and median walls of the sinus. It, however, remains that in the vast majority of cases, where these walls are simultaneously bulging into the cavity, the sinus is correspondingly reduced in size and the canine and premolar teeth not in direct relation to the sinus.

These variations in the approximation of the sinus walls, and the great difference in the extent of the various recesses, have a marked effect on the shape of the base of the cavity. A reference to figure 25 will show various shapes and sizes. Note especially case 4, in which the ventrosuperior diagonal is very short, and the dorsosuperior, because of a marked infraorbital recess, comparatively long. The great difference in the two diagonals produces a peculiarly shaped base.

THE OSTIUM MAXILLARE.

When considering the embryology of the lateral nasal wall it will be remembered that the primitive maxillary pouch had certain relations of importance. These structures were the processus uncinatus, the infundibulum ethmoidale, the hiatus semilunaris, and the bulla ethmoidalis. The location of the ostium maxillare, of the adult, corresponds to the place of the primitive maxillary pouch. This pouch gradually develops into the pyramidal cavity of the adult, leaving the place of communication with the infundibulum ethmoidale at the point of primary evagination. It is, therefore, quite evident that these structures which in the embryo bore so close a relation to the Anlage of the sinus maxillaris, must now bear even more important relations to the ostium maxillare.

On raising or removing the middle nasal concha, in the adult, a rounded elevation—the bulla ethmoidalis, is seen. This structure is directed inferiorly and ventrally. Immediately beneath it is the well defined curved margin of the processus uncinatus of the ethmoid bone. Between these structures there is a narrow slit or semilunar cleft—the hiatus semilunaris, which is from 15 to 20 mm. long. This is an important opening, for it serves as the communication between the meatus nasi medius and the gutter-like groove (infundibulum ethmoidale) formed by these structures. The bulla ethmoidalis varies considerably in size. At times it is feebly developed and again it may assume comparatively large proportions. The size of the bulla greatly influences the width of the semilunar cleft or hiatus semilunaris. The bulla may be so large that its convexity comes in direct contact with the free margin of the processus uncinatus of the ethmoid bone. In other cases the hiatus semilunaris may be of considerable width.

It is easy to conclude what effect these conditions will have on the ostium maxillare directly, and on the sinus maxillaris indirectly. In one case the cleft of communication between the ostium maxillare and the meatus nasi medius is practically shut off, while in the other case a freer communication exists. It must be remembered that, even though the bulla touches the free margin of the processus uncinatus—thus greatly narrowing the hiatus semilunaris, the infundibulum ethmoidale may be of average dimensions. This is an important fact,

and must always be borne in mind when considering the frontomaxillary relations.

The processus uncinatus with its covering of mucous membrane projects inferiorly and dorsally. By its free superior border it forms the inferior boundary of the hiatus semilunaris. This process frequently terminates dorsally in what may be termed two roots; the inferior one passes towards the superior edge of the concha nasalis inferior, while the superior root curves superiorly behind the dorsal termination of the bulla ethmoidalis (Figs. 28 and 29). Such a condition, as the latter, causes the infundibulum ethmoidale to end dorsally in a pocket. This fact is of extreme importance, because the pocket is so situated that it will direct any fluid coming to the dorsal end of the infundibulum ethmoidale into the sinus maxillaris, via the ostium maxillare which is in the immediate location.

The infundibulum ethmoidale is a groove or gutter situated upon the lateral nasal wall. It is bounded superiorly by the inferior surface of the bulla ethmoidalis throughout the greater part of its extent, save ventrally and superiorly where the bulla is replaced by some anterior ethmoidal cells. The inferior and medial boundary of the groove is formed by the lateral surface of the processus uncinatus. This groove communicates with the meatus nasi medius through the hiatus semilunaris. The infundibulum may end, as stated above, in a pocket; or may lose its depth gradually and be lost in the meatus nasi medius (Figs. 28, 29, 30). The superior and ventral end of the infundibulum may terminate blindly without dilatation, or in an air cell; or may be continuous with the nasofrontal duct. The lateral wall of the infundibulum is formed partly by mucous membrane. The depth of this gutter-like channel, or the distance from the superior border of the processus uncinatus to the floor of the groove, varies from 1 to 12 mm., with approximately an average of 5 mm.

The sinus maxillaris communicates indirectly with the meatus nasi medius by means of an opening—the ostium maxillare—which pierces the superior and ventral part of the base of the cavity to open into the infundibulum ethmoidale, thence via the hiatus semilunaris into the meatus nasi medius. It must be clearly kept in mind that the ostium is located in the superior part of the sinus, and that it opens into the in-

fundibulum ethmoidale and not into the hiatus semilunaris, as many writers say. The ostium maxillare may be either in the most dependent part of the infundibulum or in the lateral wall of this channel. This opening varies in distance from the hiatus semilunaris from 1 to 12 mm. This distance is dependent upon the width of the processus uncinatus and the resultant depth of the infundibulum ethmoidale at this point.

The ostium may be round, but as a rule is either oval or elliptical. In my series of 90 cases it has a great range of dimensions; varying from 1 to 20 mm. in length, and from 1 to 6 mm. in width. In some cases where the ostium has reached considerable size it may almost entirely replace the lateral wall of the infundibulum ethmoidale, thus forming a long, slit-like communication between the sinus maxillaris and the infundibulum ethmoidale (Fig. 26) (Table D, Nos. 7 to 12).

The following table gives an idea of the range of dimensions of the ostium maxillare, as found in the series of specimens studied:

TABLE D.

Number	Length mm.	Width mm.
1	1	1
2	3	3
3	3	2
4	5	3
5	7	4
6	8	3
7	10	6
8	11	4
9	11	6
10	14	3
11	19	3
12	20	3

THE OSTIUM MAXILLARE ACCESSORIUM.

In many cases the sinus maxillaris has an accessory ostium communicating directly with the meatus nasi medius—the ostium maxillare accessorium. This opening is, as a rule, situated in the membranous portion of the lateral wall of the meatus nasi medius a short distance above the superior border

of the concha nasalis inferior, at about the junction of its middle and posterior thirds. In some instances the accessory ostium is placed immediately behind the dorsal termination of the infundibulum ethmoidale (Fig. 27). This accessory ostium must not be confused with the duplication of the ostium maxillare, which communicates with the infundibulum ethmoidale.

According to Chiari and Hajek an accessory opening is found in every fifth case in the meatus nasi medius, posterior and inferior to the normal aperture. Giraldès says it is found in 10 per cent of cases, and represents a pathologic condition. Zuckerkandl and Kallius report it present in 10 per cent of cases. Turner found it four times in nine dissections.

That this accessory opening occurs more frequently than is generally supposed seems proven by the study of 80 adult specimens. Out of 80 specimens examined 35 showed accessory ostia, or a percentage of 43; while three cases had two accessory ostia, or a percentage of 3.75. From this it seems that the former figures were much too low. Whether this series had a special run for accessory ostia or whether too few specimens were used in the former reports is of course not known. It may, however, be said that the opening occurs very frequently and that the earlier reports, apparently, placed the percentage of occurrence far too low.

Just what the ostium maxillare accessorium means in all cases is indeed difficult to say. It seems almost incredible that so large a percentage of specimens should have pathologic openings. Giraldès bases his claim of a pathologic origin on the facts that the accessory ostium is absent in the young individual, and that the mucous membrane becomes thinned out in this locality—even though the opening fails to establish itself. Zuckerkandl corroborates the thinning of the mucous membrane in this locality at times, but claims that we have no evidence that it is always a pathologic process causing this condition. He says that occasionally the accessory opening is caused by neighboring structures:

"Seltenenfalls entsteht ein Ostium maxillare accessorium durch Druck von Seite nachbarlicher Organe; ich habe gesehen, das ein abnorm breiter zugespitzer Hakenfortsatz der Nasenscheidewand an der hinteren Nasenfontanelle eine Durchlocherung veranlasst hatte."

I have not found the accessory ostium present in the fetus and infant. Unfortunately I have been unable to secure a sufficient number of specimens between the ages of 6 and 15 years to draw any conclusions of value on the occurrence of the ostium maxillare accessorium during this period of time. I found the accessory opening occasionally present in the young adult—17 to 20 years. The specimens (adult) studied ranged in age from 17 to 80 years, with the majority from subjects over 50 years old. That some cases of accessory ostia are of pathologic origin is doubtless true, but many cases certainly do not give any evidence of a pathologic process. The thinning of the mucous membrane, of which Giraldès and Zuckerkandl speak, is very evident in many specimens. I, however, believe with Zuckerkandl that we must, in the majority of cases, look elsewhere than to a pathologic process for the determining factor in this condition.

In this connection it is important to note that out of the 35 sinus maxillares having accessory ostia, 27 of them had positive relations with the sinus frontalis, i. e., the infundibulum ethmoidale continuous with the nasofrontal duct. This would indicate that 77 per cent of sinus maxillares having positive frontomaxillary relations have accessory ostia communicating directly with the meatus nasi medius.

Another explanation for this accessory ostium may be found in the fact that since the sinus maxillaris develops by the growth of the sac and resorption of surrounding bone, its walls have a tendency to become thinned out most at points of least resistance. Such a point is found in the membranous portion of the base of the sinus, where bone is entirely wanting —the usual seat of the accessory opening. The mucous membrane in this position may become thinned out to such an extent, by the growth of the sinus, that an opening is formed; thus establishing the ostium maxillare accessorium.

Since the ostium maxillare opens into the infundibulum ethmoidale, and secondarily by way of the hiatus semilunaris into the meatus nasi medius, it is apparent that the ostium maxillare accessorium, with its more dependent location and direct communication with the meatus nasi medius, is more advantageously placed as a drainage opening for the sinus maxillaris. In some cases the ostium maxillare certainly seems inadequate—due to its position, relations and size—to

properly drain the sinus. Why then may we not say that this accessory ostium, in some cases, of necessity comes to be formed as a means by which the sinus maxillaris can more readily dispose of accumulated fluid? The process by which this is brought about need not necessarily be termed pathologic. Doubtless more information is necessary on this point before we dare draw conclusions.

Of course some specimens present accessory ostia which look decidedly pathologic; and as Zuckerkandl points out some are due to pressure caused by neighboring structures. I hope to study the subject more extensively in the embryo and child to see whether the opening, after all, at times, does not have an embryologic significance. Thus far I must agree with Giraldès that the ostium maxillare accessorium does not appear in the embryo and young child.

The accessory ostium varies much in size. In the series I studied the range of measurements was from 1 to 10 mm. long and from one-half to 10 mm. wide. The opening may be round or elliptical.

The appended table selected from a series of 80 specimens gives the range in size:

TABLE E.

Long mm.	Wide mm.
1	½
2	1
4	4
6	4
7	5
10	10

THE FRONTOMAXILLARY RELATIONS.

It is interesting to note that Nathaniel Highmore (1651) recognized the fact that the sinus maxillaris at times receives fluid from other sources. In his brief description of the cavity (see previous paragraph) he makes brief mention of this important condition.

"Antrum hoc frequentius vacuum, aliquando muco repletum reperitur, in quod humores a capite per meatum quendam a cavitate illa in osse frontis, et ab osse ethmoeide distillare poterunt."

Although mentioning that fluid from the cavities in the frontal and ethmoid bones occasionally reaches the sinus maxillaris by way of the "meatum," he does not attempt to explain how this is brought about.

[illegible]aux ('40) found when injecting fluid into the sinus frontalis that some of it passed into the sinus maxillaris, instead of the whole amount passing into the meatus nasi medius. Cryer ('94, '01, '07), Fillibrown ('96, '97), reported on frontomaxillary relations. Lothrop's investigations ('98) show that in 47 per cent of cases the infundibulum ethmoidale is continuous with the nasofrontal duct, while 53 per cent show that the infundibulum ethmoidale has no connection with the sinus frontalis. Turner ('01) speaks briefly about the relation, and Wilson ('08) in his paper on the "Variations of the Ostium Frontale" alludes to this important relation. Some clinicians have reported isolated cases where they believed the maxillary trouble secondary to pre-existing frontal trouble, without, however, attempting to explain any anatomic conditions which would justify the clinical conclusions.

In order to secure the frontomaxillary relations in the specimens at hand, I undertook a series of investigations, including special dissections, filling the sinus frontalis with a fluid to determine the direction of drainage, and the determination of the efficiency of the infundibulum ethmoidale as a carrier of fluid.

It will be remembered that the infundibulum ethmoidale at its superior and ventral termination is either continuous with the nasofrontal duct, or ends blindly without dilatation, or in an air cell. The cases where it is continuous with the nasofrontal duct or with the sinus frontalis directly, represent what will be here spoken of as the positive frontomaxillary relations. Where the infundibulum ends blindly or in an air cell, the conditions will be spoken of as negative frontomaxillary relations.

According to the specimens I examined, the sinus frontalis may discharge fluid put into it in one of the following ways:

a. By the nasofrontal duct or the sinus frontalis being continuous with the infundibulum ethmoidale (in some cases there is no nasofrontal duct and the sinus frontalis is directly continuous with the infundibulum ethmoidale) (positive relation) (Fig. 28).

b. By the nasofrontal duct communicating directly with the meatus nasi medius (negative relation) (Fig. 29).

c. By a combination of the above conditions—in which case the sinus frontalis had two nasofrontal ducts; one continuous with the infundibulum ethmoidale, and the other communicating directly with the meatus nasi medius (positive and negative relations) (Fig. 30).

d. By the nasofrontal duct being continued down to the infundibulum ethmoidale at an angle; and in conjunction there being a passageway between the ventral attachment of the concha nasalis media and the processus uncinatus of the ethmoid bone, to the meatus nasi medius (considered as positive relations).

e. By a direct communication between the sinus maxillaris and the sinus frontalis, by what may be termed the maxillofrontal duct (direct relation) (Fig. 26).

Of the 80 specimens studied to ascertain the frontomaxillary relations, 45 showed a positive relation, or a percentage of 56.25; 32 a negative relation, or a percentage of 40; 2 a combination of positive and negative, or a percentage of 2.5; 1 a direct communication between the two sinuses, or a percentage of 1.25.

The importance of the above conditions was in each case tested by putting fluid into the sinus frontalis to determine the course of drainage. It at once became apparent that the specimens falling under classes (*a*) and (*d*) should be classed together as representing positive frontomaxillary relations. The only difference in the above two conditions is that in class (*a*) all of the fluid put into the sinus frontalis will reach the superior and ventral part of the infundibulum ethmoidale; while in class (*d*) some of it will pass directly into the meatus nasi medius, and the remaining portion to the infundibulum ethmoidale

Class (*b*) will drain fluid from the sinus frontalis directly into the meatus nasi medius. It is, however, important to know that even in these cases some fluid may reach the infundibulum ethmoidale, because of the intimate relations existing between the nasofrontal duct and the superior and ventral end of the infundibulum ethmoidale (Fig. 29).

Class (*c*), where the sinus frontalis has two nasofrontal ducts, the drainage is of course partly into the meatus nasi

medius and partly into the infundibulum ethmoidale. This class leads to similar results as mentioned above, the only difference being that the infundibulum does not receive as much fluid in a given time.

Class (*e*) fortunately represents a rare condition. Here the sinus frontalis drains directly into the sinus maxillaris. In the specimen I found with this direct relation there was also a communication between the infundibulum ethmoidale and the sinus frontalis. Cryer, Bryan, and Brophy have reported direct relations between the two sinuses, which I have been able to verify in this one specimen. In cases where the lateral wall of the infundibulum ethmoidale is largely wanting, fluid from the frontal sinus (providing the infundibulum ethmoidale is continuous with the nasofrontal duct) will pass almost directly into the sinus maxillaris, and will, therefore, very closely simulate a direct communication between the two sinuses. A probe passed from the sinus frontalis will, in such cases, also pass into the sinus maxillaris. Doubtless some of these cases have been considered by some clinicians as direct communications, whereas a further dissection would have proved them otherwise (Fig. 26).

The question now arises—what happens to the fluid that has reached the superior and ventral end of the infundibulum ethmoidale? In the first place it may be said that the efficiency of the infundibulum ethmoidale, as a carrier of fluid, is in direct ratio to its depth and to the degree of overhanging of the mucous membrane from the free border of the processus uncinatus of the ethmoid bone. In some cases the processus uncinatus is so narrow that the infundibulum ethmoidale has no appreciable depth at its superior end, and in these cases the fluid which has reached it from the frontal region will soon leave the shallow groove after entering it—at least a goodly portion of it. In other cases the processus uncinatus is broad, and the resultant infundibulum ethmoidale deep and channel-like. It must also be recalled that in a previous paragraph mention was made of the fact that frequently the infundibulum ethmoidale ends dorsally in a pocket, so situated that it will direct the flow of fluid coming to the dorsal end of the infundibulum ethmoidale into the ostium maxillare—thence into the sinus maxillaris (the ostium maxillare beng patent) (Figs. 28, 29).

We have, therefore, a gutter-like channel, of varying depth and efficiency, communicating between the frontal region and the sinus maxillaris; including the sinus frontalis in 56 per cent of cases and some of the cellulæ ethmoidales anterior in nearly all cases.

In the cases where the infundibulum ethmoidale does not end in a pocket dorsally (Fig. 30), much of the fluid that would otherwise be directed into the sinus maxillaris by this pocket, passes from the dorsal termination of the infundibulum ethmoidale into the meatus nasi medius. This, however, makes little difference—the very fact that some of the fluid gets into the sinus maxillaris makes the condition similar to the above. It requires merely more time to accomplish the same end result—a filled sinus maxillaris.

In case the ostium maxillare is not patent, the fluid after reaching the dorsal end of the infundibulum ethmoidale rises in the channel and finally passes through the hiatus semilunaris into the meatus nasi medius.

That the sinus maxillaris, because of its position and relations, is a reservoir for some or all of the fluid coming to the dorsal end of the infundibulum ethmoidale, is a fact that admits of no debate (the ostium maxillare being patent).

IMPORTANT NERVE RELATIONS OF THE SINUS MAXILLARIS.

The roof or orbital wall of the sinus maxillaris is traversed by the infraorbital sulcus and the infraorbital canal. These passageways transmit the infraorbital vessels and nerve (considering the maxillary nerve as the infraorbital nerve from the proximal end of the infraorbital sulcus on). As a rule, the canal has comparatively thick walls, but in many cases the inferior wall of the canal is of a papery delicacy and is easily compressed against the contained nerve and vessels. Frequently the canal is replaced by a groove, with the opening of the groove directed towards the sinus maxillaris. The structures—infraorbital nerve and vessels—contained in the groove are merely covered with the mucous membrane of the sinus.

The posterior superior alveolar (dental) nerves, branches of the maxillary nerve, in most of my cases were found to pass inferiorly and ventrally upon the infratemporal surface of the maxilla, through the alveolar foramina into the alveolar canals. They thus aided in the formation of the superior

dental plexus of nerves. Occasionally some of the branches of these nerves, instead of taking the above course, passed entirely through the infratemporal surface of the maxilla into the sinus maxillaris. They then passed under cover of the mucous membrane of the sinus inferiorly and ventrally to the sinus floor; thence to the superior dental plexus.

The middle superior alveolar (dental) nerve, a branch of the infraorbital nerve, was as a rule given off in the proximal part of the infraorbital canal. It passed inferiorly and ventrally in a canal in the lateral wall of the sinus maxillaris and aided in establishing the superior dental plexus of nerves. The nerve I found in one case to arise from one of the anterior superior alveolar nerves. It also rarely passed under cover of the mucous membrane of the sinus to the superior dental plexus.

The anterior superior alveolar (dental) nerve was given off from the infraorbital nerve, proximal to the infraorbital foramen. It passed inferiorly in the alveolar canal of the anterior surface of the maxilla and took part in forming the superior dental plexus of nerves. From this plexus arose the superior dental nerves which supply the fangs of the teeth, the gums, and give numerous branches to the maxilla and the mucous membrane of the sinus maxillaris.

I also observed—a very important condition—that in one case the anterior superior alveolar nerve came off from the infraorbital nerve quite a distance proximal to the infraorbital foramen. The nerve then passed through the inferior wall of the infraorbital canal and took a course diagonally across the sinus from the roof to its ventral wall. The nerve thus suspended freely in the cavity of the sinus maxillaris was surrounded merely with mucous membrane (Fig. 31).

CONCLUSIONS.

1. The Anlage of the sinus maxillaris appears during the third month of fetal life as a minute epithelial sac evaginating and growing at first inferiorly, later more laterally, from the dorsal end of the primitive infundibulum ethmoidale.

2. The primitive maxillary pouch may be duplicated. In some cases this may account for the duplication of the ostium maxillare of the adult sinus, i. e., the two pouches fusing distally, leaving the two points of evagination as the adult

ostia. Other duplications of the ostium may develop in a way similar to that of the accessory ostium.

3. The primitive ostium maxillare varies very much in its dimensions in different embryos. This is entirely in accord with adult conditions, since the ostium of the adult sinus has a great range of dimensions.

4. Dentition seems to influence the size of the cavity but little. The age of the child and the size of the sinus apparently progress pari passu.

5. The cavity enlarges by the simultaneous growth of the sac and the resorption of surrounding tissue. These two processes taking place pari passu with the growth of the face.

6. In a fetus at term the ventrodorsal measurement of the sinus is about 7 mm., and in a child aged 20 months it is about 20 mm. The cavity reaches its full size from the fourteenth to the eighteenth year.

7. The following may be given as average measurements of the adult sinus maxillaris, based on the measurements of 90 adult specimens:

		mm.
1	Dorsosuperior diagonal	38
2	Ventrosuperior diagonal	38.5
3	Superoinferior	33
4	Ventrodorsal	34
5	Mediolateral	23

8. The range in capacity of the sinuses studied to ascertain this fact was from 9.5 cc. to 20 cc., with an average of 14.75 cc.

9. In the majority of cases the sinus floor is at an inferior level to the nasal floor. This distance varies from one-half to 10 mm. Sex has little influence on this relation.

10. The number of teeth that bear a direct relation to the sinus is inconstant, due to the great difference in the size of the cavity in different individuals. The three most constant teeth in direct relation are the three molars.

11. The tooth fangs may cause the formation of elevations on the sinus floor. Occasionally the fangs of some teeth are in direct communication with the mucous membrane of the cavity.

12. Frequently the walls of the sinus are uneven, due to ridges, or crescentic projections. These prominences form

pockets and recesses within the cavity. Occasionally the cavity is divided by a septum into two distinctly separate compartments, each having an independent opening into the nasal fossa, but not communicating with each other.

13. The adult sinus varies much in size in different individuals, and the asymmetry on the two sides of the same individual is often marked.

14. Age, sex, and side (right or left) influence the size of the adult sinus but little.

15. The adult ostium maxillare varies much in size. It is located in the superior and ventral part of the base of the cavity, and serves as a means of communication between the sinus maxillaris and the infundibulum ethmoidale. Occasionally it replaces the greater portion of the lateral wall of the infundibulum ethmoidale, and represents a slit-like aperture. The ostium may be duplicated.

16. The ostium maxillare accessorium is of very frequent occurrence. It serves as a means of direct communication between the sinus maxillaris and the meatus nasi medius. In my series of specimens it was present in 43 per cent of cases. The aperture was not found in the fetus and infant.

17. Most of the accessory ostia do not look pathologic, and the writer believes that we must, in many cases, look elsewhere than to a pathologic process for the determining factor in this condition.

18. Of the specimens studied to ascertain the frontomaxillary relations, 56 per cent showed that the infundibulum ethmoidale was intimately related with the nasofrontal duct or with the sinus frontalis directly—in case the nasofrontal duct was wanting; 40 per cent showed that the nasofrontal duct communicated directly with the meatus nasi medius—the infundibulum ethmoidale ending blindly or in an air cell; 2.5 per cent showed two nasofrontal ducts, one continuous with the infundibulum ethmoidale, and the other communicating with the meatus nasi medius; 1.25 per cent showed a direct communication between the sinus frontalis and maxillaris.

19. Since the infundibulum ethmoidale receives the ostium maxillare at its dorsal and inferior end in all cases, and the nasofrontal duct, or the sinus frontalis directly, at its ventral and superior end in over one-half the cases, it very frequently serves as a gutter-like channel, of varying depth and

efficiency, communicating between the frontal region and the sinus maxillaris.

20. The sinus maxillaris, therefore, acts as a reservoir for fluids coming to the dorsal end of the infundibulum ethmoidale (the ostium maxillare being patent).

21. Frequently the processus uncinatus by a superior curving at its dorsal end causes the infundibulum ethmoidale to end in a pocket. This pocket is so situated that it directs fluids coming to the dorsal end of the infundibulum ethmoidale into the sinus maxillaris—via the ostium maxillare which is in the immediate vicinity.

22. Occasionally branches of the superior alveolar nerves in passing to the superior dental plexus pass entirely through the walls of the sinus, thence under cover of the mucous membrane of the cavity to their destination. Rarely the anterior superior alveolar ramus, instead of taking its usual course, passes diagonally from the roof of the sinus to its ventral wall—the nerve thus suspended freely in the cavity is merely covered with the mucous membrane.

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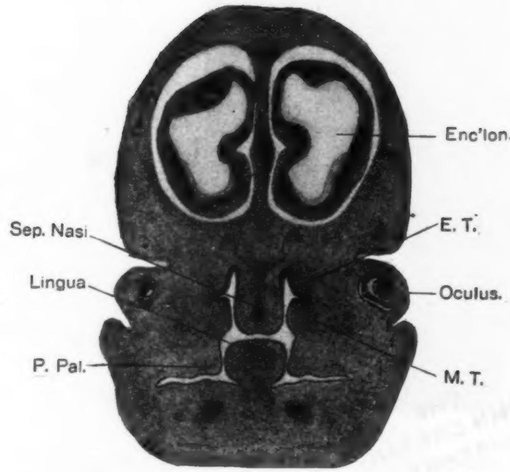

Figure 1 (× 10). Drawing of a frontal section through the head of an embryo aged about 45 days, in the region immediately dorsal to the organon vomeronasale (Jacobsoni), note the development of the early turbinal processes, and that there is no cartilage laid down in them at this early period. This is contradictory to the theory that the turbinal processes are primarily the result of an inpushing of the lateral nasal wall by cartilaginous strands which later become the nasal conchae.

Enc'lon, = encephalon; E. T., = ethmo-turbinalia; M. T., maxillo-turbinale; P. Pal., = processus palatinus; Sep. Nasi, = septum nasi.

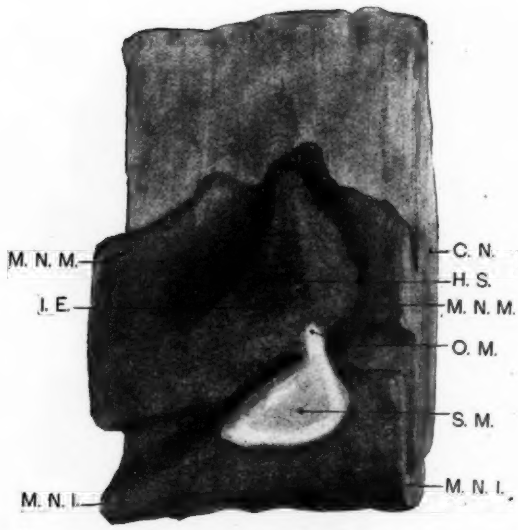

Figure 2 (×10). Drawing of a reconstruction of portion of the right nasal cavity, including the meatus, infundibulum ethmoidale, and the sinus maxillaris. Only that portion of the nasal cavity necessary to include the sinus maxillaris and its relations is shown.

Compare the size of the ostium maxillare with the corresponding aperture in Figure 3.

The model was reconstructed from the nose of an embryo aged 105 days. It must be remembered that the drawing represents cavity, and is, therefore, a negative.

M. N. M., M. N. I., = meatus nasi, medius et inferior; I. E., = infundibulum ethmoidale; C. N., = cavum nasi; H. S., = hiatus semilunaris; O. M., = ostium maxillare; S. M., = sinus maxillaris.

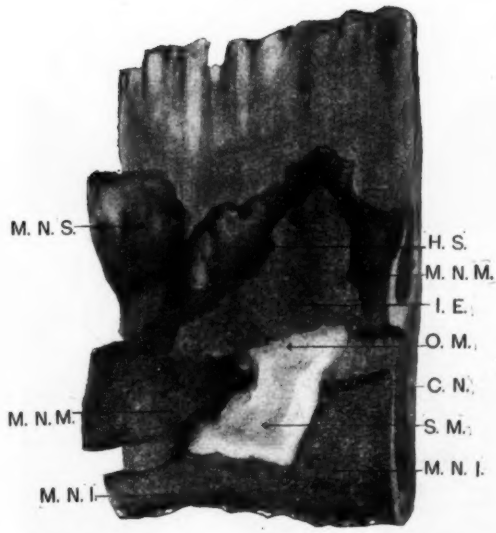

Figure 3 (× 10). Drawing of a reconstruction of portion of the right nasal cavity of an embryo aged 120 days. The drawing includes the meatus, infundibulum ethmoidale, and the sinus maxillaris. Only that portion of the cavity was modeled so as to include the sinus maxillaris and its relations. Since it represents cavity it is a negative.

Note the very extensive ostium maxillare in comparison to that in figure 2.

M. N. S., = meatus nasi superior; M. N. M., M. N. I., = meatus nasi, medius et inferior; I. E., = infundibulum ethmoidale; C. N., = cavum nasi; H. S., = hiatus semilunaris; O. M., = ostium maxillare; S. M., = sinus maxillaris.

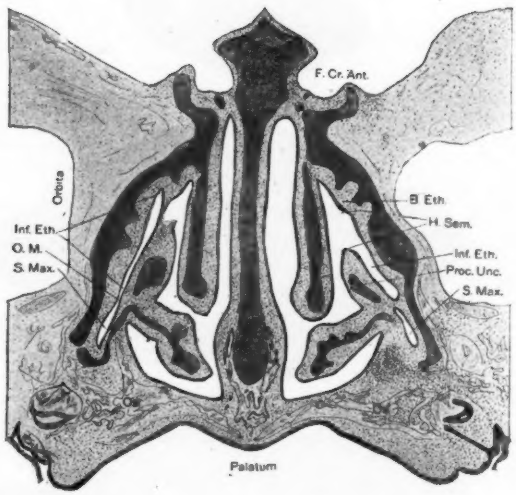

Figure 4 (× 6.6). Drawing of a frontal section of the nose of an embryo aged 120 days. The section is 7.25 mm. from the tip of the nose. Note that on one side the section is in the region of the ostium maxillare, on the other it is dorsal to it; also the fusion between the processus uncinatus and a frontal concha.

Inf. Eth., = infundibulum ethmoidale; O. M., = ostium maxillare; S. Max., = sinus maxillaris; Os., = developing bone; F. Cr. Ant., = fossa cranii anterior; B. Eth., = bulla ethmoidalis; H. Sem., = hiatus semilunaris; Proc. Unc., = processus uncinatus.

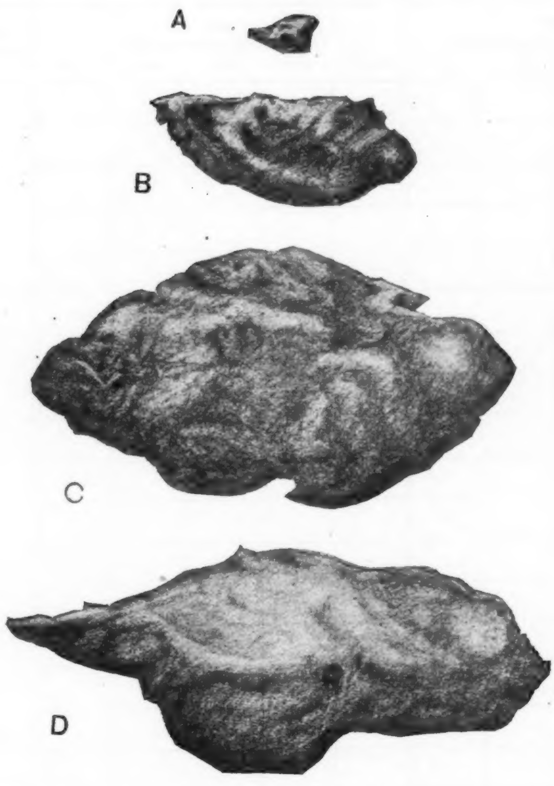

Figure 5 ($\times$ 4). Drawings of the mucous membrane, representing the exact shapes of the sinus maxillaris at different stages of its development in the fetus and child.

A. From a fetus aged 4 months. B. From a fetus at term. C. From a child aged 18 to 20 months. D. From a child aged 20 to 23 months.

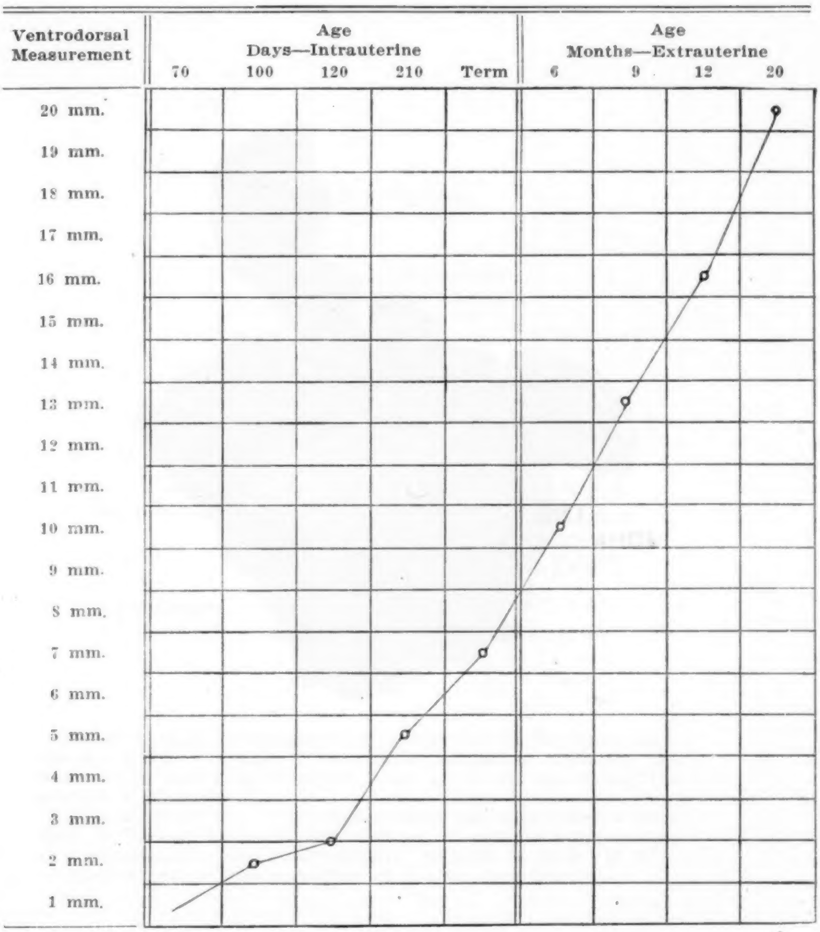

Figure 6. Chart showing the gradual increase in size of the sinus maxillaris in its ventrodorsal plane.

Figure 7 (0.9). Photograph of a dissection of the sinus paranasales of the left side. The mucous membrane is shown, the bony walls have been dissected away after first hardening the subject in formalin.

C. N. M., C. N. Inf., = conchae nasales, media et inferior; Sep. Nasi, = septum nasi; Cc. Ethmoidales, = cellulae ethmoidales; S. Sphenoidalis, = sinus sphenoidalis; M. N. S., M. N. M., M. N. I., = meatus nasi, superior, medius, et inferior, respectively.

Figure 8 (× .385). Photograph of a dissection of the sinus maxillaris and frontalis from a ventral view.
S. Fron., S. Max., = sinus frontalis et maxillaris, respectively.

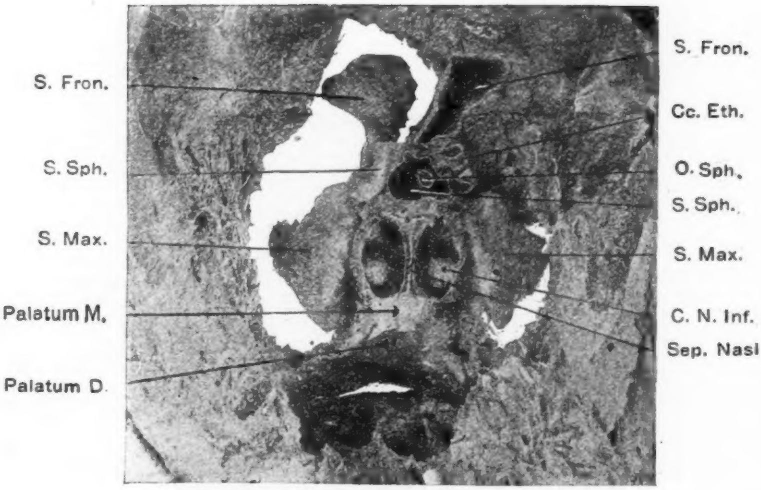

Figure 9 (× .64). Photograph of a dissection of the sinus paranasales from a dorsal view. The mucous membrane of the cavities is shown, the bony walls have been dissected away. The sinus frontalis and sphenoidalis, and the cellulae ethmoidales of the right side have been opened.

S. Fron., S. Sph., S. Max., = sinus frontalis, sphenoidalis, and maxillaris, respectively; Palatum M., Palatum D., = palatum molle and palatum durum, respectively; Cc. Eth., = cellulae ethmoidales; O. Sph., = ostium sphenoidale; C. N. Inf., = concha nasalis inferior; Sep. Nasi, = septum nasi.

Figure 10 (× .8). Photograph of a frontal section of a child's face aged from 16 to 18 months. Note the infraorbital canal and nerve, and the relation of the sinus maxillaris to the developing teeth. It will be noticed that the sinus maxillaris has developed sufficiently to reach beneath the orbit, but that it is medial to the infraorbital canal.

C. Info., = canalis infraorbitalis; S. Max., = sinus maxillaris.

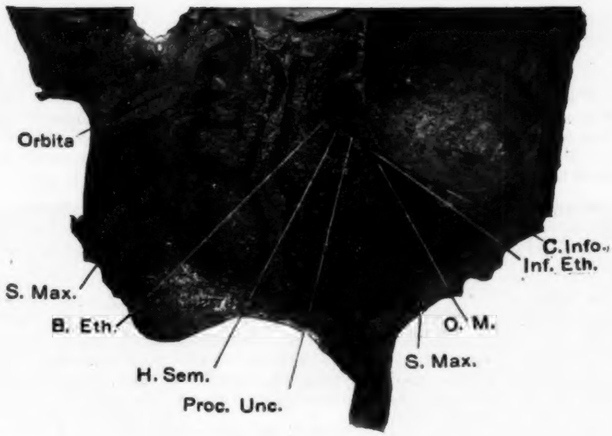

Figure 11 (× .8). Photograph of a frontal section of an adult's face in the region of the sinus maxillaris. Note the location of the ostium maxillare and the infundibulum ethmoidale. Although the section is not exactly a frontal one, there is nevertheless a marked asymmetry in the size of the two sinus maxillares. There is also quite a difference in the relation of the sinus floor to the nasal floor on the two sides.

S. Max., = sinus maxillaris; B. Eth., = bulla ethmoidalis; H. Sem., = hiatus semilunaris; Proc. Unc., = processus uncinatus; C. Info., = canalis infraorbitalis; Inf. Eth., = infundibulum ethmoidale; O. M., = ostium maxillare.

Figures 12 to 17. Photographs of dissections showing variations in the teeth relations of the sinus maxillaris.

Figures 12, 13 ($\times$ .48). Note the short ventrosuperior diagonal of the sinus maxillaris, due to the simultaneous approximation of the ventral wall and the base of the sinus. As a result, the only teeth in direct relation to the cavity are the second and third molars.

Figure 14 ($\times$ .456). Note that the premolar teeth are not in direct relation, and that the canine tooth, as in the preceding figures. would certainly be a bad tooth to use in attempting to drain the cavity through the canine socket.

Figure 15 ($\times$ .48). This figure shows to what extreme the body of the maxilla may be hollowed out by the sinus maxillaris. Note the very delicate walls of the cavity, especially the shell-like alveolar process. Due to the extensive recessus alveolaris the "remaining tooth" projects into the lumen of the cavity and is merely covered with the mucous membrane of the sinus.

Figure 16 ($\times$ .552). Although the processus alveolaris is comparatively thick, the second-molar tooth fangs just reach the mucous membrane of the cavity. Note the large ostium maxillare accessorium.

Figure 17 ($\times$ 1.28). Showing the relations of the developing teeth to the sinus maxillaris, of a child aged from 18 to 20 months. Note the position of the Anlagen of the permanent teeth.

S. Max., = sinus maxillaris; C. P., = crescentic projection; D. p. r., = dentes permanentes rudimentii; Sep. Nasi, = septum nasi; F. Info., = foramen infraorbitale; D. d., = dentes decidui.

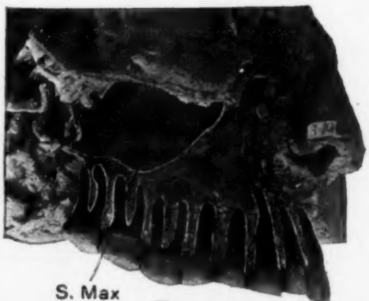

Fig. 12

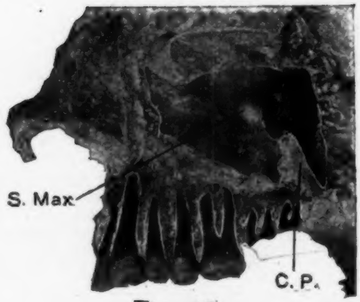

Fig. 13

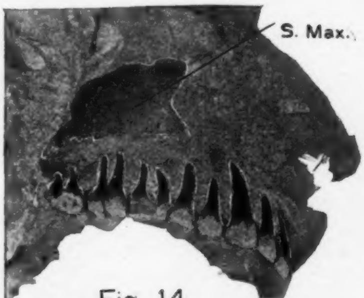

Fig. 14

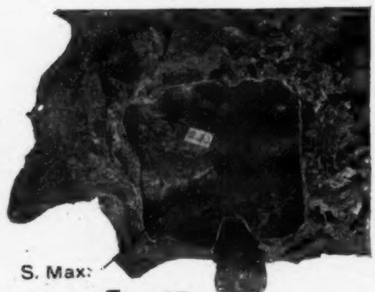

Fig. 15

Fig. 16

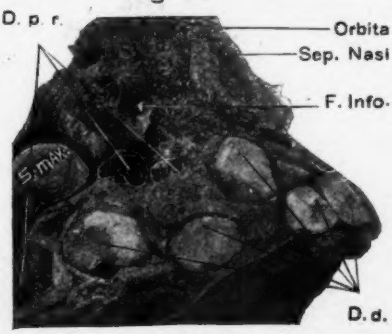

Fig. 17

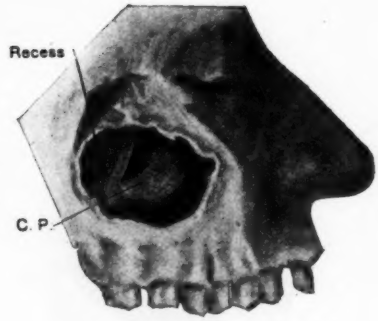

Fig. 18

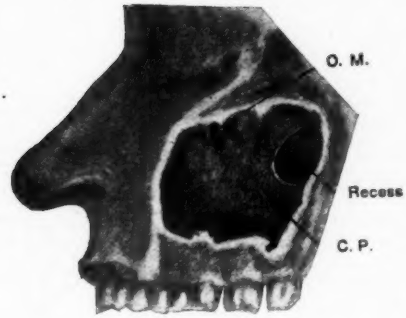

Fig. 19

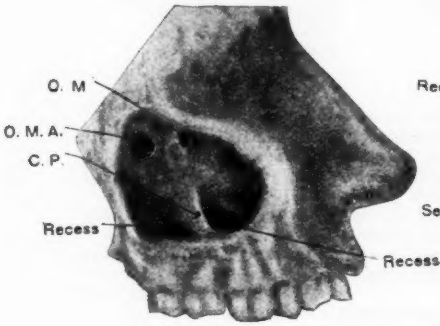

Fig. 20

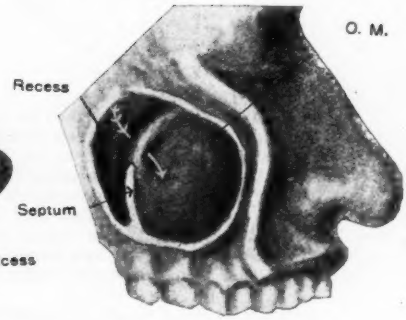

Fig. 21

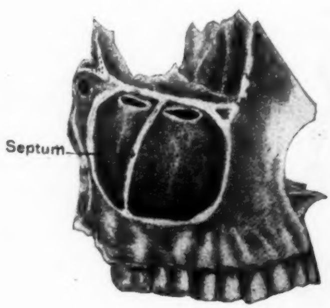

Fig. 22

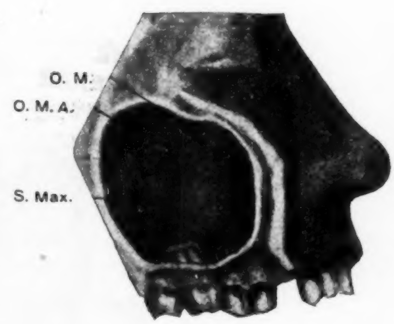

Fig. 23

Figures 18 to 23 Drawings of specimens showing septa and crescentic projections on the walls of the sinus maxillaris. Note how these projections form recesses within the cavity. (Figure 22 is modified from E. Zuckerkandl, Normale und pathologische Anatomie der Nasenhöhle und ihrer pneumatischen (Anhaenge).

C. P., = crescentic projection; O. M., = ostium maxillare; O. M. A., = ostium maxillare accessorium; S. Max., = sinus maxillaris.

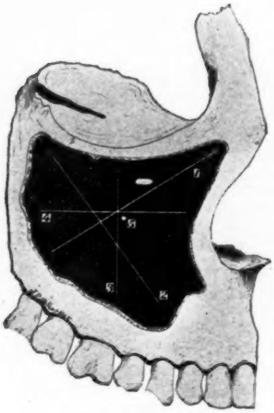

Figure 24.

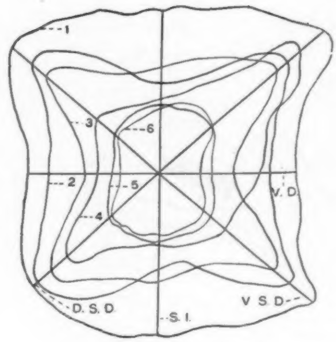

Figure 25.

Figure 24. Schematic drawing of the right maxilla. The ventrolateral wall of the sinus maxillaris has been removed, thus exposing the base or median wall of the cavity. The lines drawn on the base indicate the position of the several measurements.

1, Dorsosuperior diagonal; 2, Ventrosuperior diagonal; 3, Superoinferior; 4, Ventrodorsal; 5, Mediolateral.

Figure 25 (× 1). Composite chart showing how anatomic variations in the extent of the recesses and the approximation of the walls of the sinus maxillaris affect the shape and size of its median wall or base.

1 to 6, = outlines of different bases; V. D., S. I., V. S. D., D. S. D., = ventrodorsal, superoinferior, ventrosuperior diagonal, and dorsosuperior diagonal, respectively.

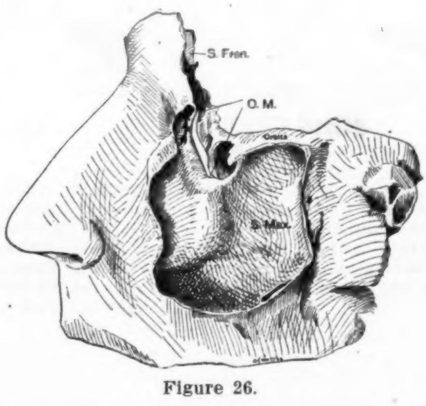

Figure 26.

Figure 26 (× .66). Drawing of a specimen showing a direct communication between the sinus frontalis and maxillaris (indicated by the arrow).

Note the very large slit-like ostium maxillare. The lateral wall of the infundibulum ethmoidale is entirely wanting.

S. Fron., = sinus frontalis; S. Max., = sinus maxillaris; O. M., = ostium maxillare.

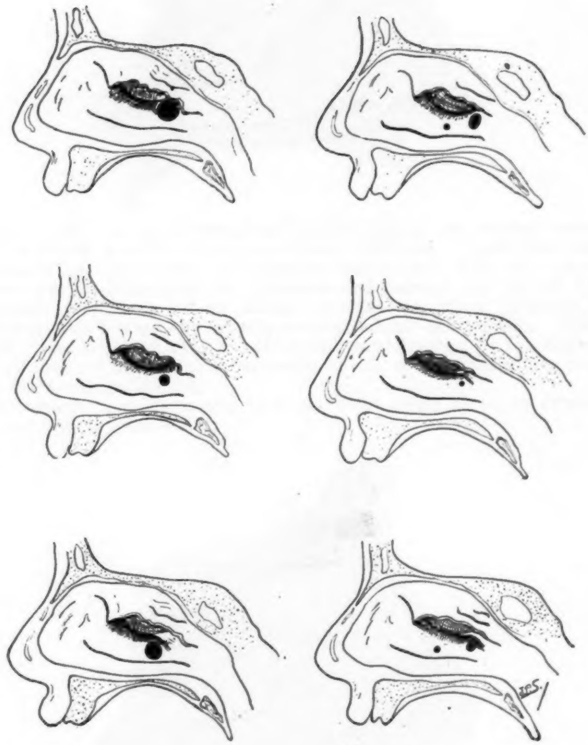

Figure 27. Diagrams of the lateral nasal wall. The conchae nasales mediae have been partially cut away so as to bring to view the underlying structures. Note the positions and varying sizes of the ostium maxillare accessorium in the different diagrams. The accessory ostia are designated by the deep black circles. The upper and lower right hand diagrams show two accessory ostia and the others but one.

Figure 28. A semidiagrammatic drawing of the lateral nasal wall showing positive frontomaxillary relations. Note that the infundibulum ethmcidale is directly continuous with the nasofrontal duct. Note also the superior and lateral curving of the processus uncinatus at its dorsal termination, thus forming a pocket at the dorsal end of the infundibulum ethmoidale. This pocket is so situated that it will direct fluid coming to the dorsal end of the infundibulum ethmoidale to the ostium maxillare and into the sinus maxillaris.

The concha nasalis media is in part cut away so as to expose the underlying structures.

Figure 29. A semidiagrammatic drawing of the lateral nasal wall of the concha nasalis media partially removed. Note that the infundibulum ethmoidale terminates blindly at its superior and ventral end. The nasofrontal duct communicates directly with the meatus nasi medius and not with the infundibulum ethmoidale as in the preceding figure (28). This represents negative frontomaxillary relations.

C. N. Sup., C. N. Med., C. N. Inf., = conchae nasales, superior, media and inferior; S. Sph., = sinus sphenoidalis; S. F., = sinus frontalis; B. Eth., = bulla ethmoidalis; Inf. Eth., = infundibulum ethmoidale; Proc. Unc., = processus uncinatus.

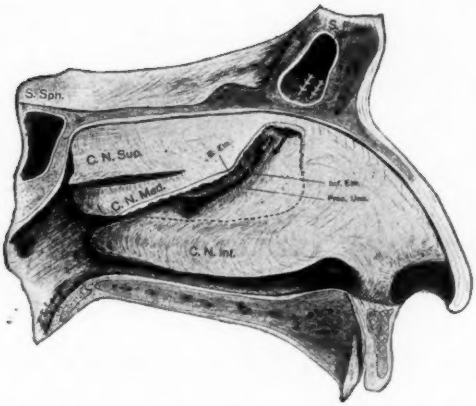

Figure 30. A semidiagrammatic drawing of the lateral nasal wall showing that the sinus frontalis, in this case, has two naso-frontal ducts, one communicating with the infundibulum ethmoidale and the other with the meatus nasi medius.

Note that the infundibulum ethmoidale terminates at its dorsal extremity in the meatus nasi medius without a pocket formation (compare this condition with figs. 28, 29).

C. N. Sup., C. N. Med., C. N. Inf., = conchae nasales, superior, media and inferior; S. Sph., = sinus sphenoidalis; S. F., = sinus frontalis; B. Eth., = bulla ethmoidalis; Inf. Eth., = infundibulum ethmoidale; Proc. Unc., = processus uncinatus.

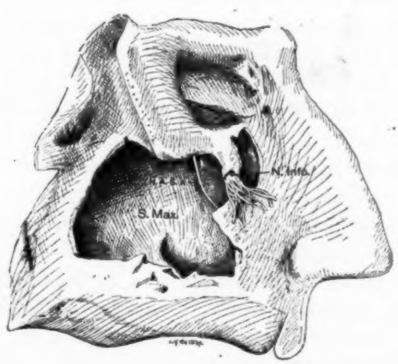

Figure 31 ($\times$ .633). Drawing from a dissection showing the anterior superior alveolar nerve (N. A. S. A.) passing diagonally from the roof or orbital wall of the sinus to the ventral or facial wall. The nerve in this position is supended freely in the cavity of the sinus maxillaris merely covered with mucous membrane.

N. A. S. A., = nervus alveolaris superior anterior; N. Info., = nervus infraorbitalis; S. Max., = sinus maxillaris.

LV.

THE EFFECT OF MAXILLARY READJUSTMENT UPON THE DEVELOPMENT OF NASAL CHAMBERS AND FACE.

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Milwaukee.

So much has been written during recent years, more especially perhaps in the last year or two, of the close relation existing between oral and nasal deformities, resulting in more active co-operation between rhinologists, oral surgeons, orthodontists and dentists, these in turn being brought more frequently into consultation with the general practitioner, that I feel it to be quite unnecessary to submit proof of the generally accepted fact that contracted dental arches and high arched palatal vaults are often associated with deviated nasal septa, contracted nares and other nasal defects and that these are commonly found together in individuals who have adenoids and enlarged tonsils. The effect of any one or all of these conditions upon health and development, both local and general, as well as upon nervous conditions and pathologic alteration of the tissues directly affected, may also be taken for granted as being so fully and generally understood as to preclude the necessity of elaboration. Our subject, stripped of these divisions, presents for consideration at this time the following features which demand attention. First: Can direct improvement of intranasal conditions be effected by treatment of dental and maxillary conditions? Second: How may this best be accomplished?

The consideration of these two questions, elementary as

they are, requires at least a cursory study of developmental principles from the very beginning of embryonic life, and of both prenatal and postnatal factors in development of the parts directly under consideration and the organism as a whole.

In the short period between the fertilization of the human ovum and the fifth to the seventh week of embryonic life we find upon examination of the sections through fetal heads that important changes have already taken place, which even at this early date are indicative of the principles that must govern our treatment in correction of deformities during the entire period of development of the individual.

It is important to note (see Fig. 1) that complete coalescence of the divisions of the forming face and the mouth, resulting from progress in this direction of the several centers from which development of the head of the embryo takes place, has not yet been completed. If, therefore, between approximately the fifth and ninth week of embryonic life, arrest of development takes place, there will be failure to unite in this particular region, the result of which will be harelip, cleft palate or both in any of the various forms in which these maldevelopments appear. Re-establishment of growth in its natural course may and usually does result in correct form of other divisions of the head and face, except in so far as they may be influenced by the effect of the disarrangement of muscular and other physiologic action through the deformity which has now become established.

Inspection of a section through the jaws at this period, under higher magnification, shows the epithelial cord which marks the appearance of the first indication of the tooth germs.

Passing in succession through a series of similar sections (Figs. 2—3) at important periods until birth, we find that in the absence of arrest or other interference with normal growth the divisions of the palate become completely united, and the spaces for the nares so much enlarged that with those of the maxillary sinuses, they occupy a very considerable portion of the facial division. The palatal surface at this time is flat, because development of the alveolar regions has not yet taken place to any considerable extent.

As the tooth follicles increase in size and their eruption thus becomes more completely established, some of them are situated high up and just outside the nares. If growth of the alveolar ridges takes place in natural form unimpeded by any factor which may tend to restrict the natural size of the arch, the developing tooth crowns, the germs for both temporary and permanent sets of which are in place before birth, can pass on downward and outward in the natural course of their eruption, thus making it possible for the nares and their dividing septum, as well as turbinal and other nasal structures, to assume in due course normal form and proportions. If, however, from any cause, whether it be surgical, mechanical, developmental or pathologic, there is interference with the natural expansion of the arch, which represents the alveolar ridge and later the dental arch, it naturally follows that there must be crowding through want of space for the tooth crowns to assume their rightful positions in relation to others that are being pushed onward by forces through the action of which tooth eruption takes place. The first effect of pressure from crowding must naturally react upon regions of the maxillæ in which the tooth crowns at this time are located. Effort at readjustment naturally takes place in the direction of least resistance. This must be in the direction of the nares, and causes in greater or less degree abnormality of form, chiefly evident in their restricted size.

The second effect is overlapping of the tooth crowns, evidenced by their eruption on the outside or the inside of the true line of the arch, resulting in labial, buccal or lingual occlusion. When the process of eruption has continued to a point where the cusps of the teeth in the occluding jaws can come in contact with each other, the muscular forces of jaw movement, acting upon the inclined planes of the cusps and the crown surfaces of the teeth, bring into play the active factors through which regular or irregular forms of dental arches are determined.

Glancing for a moment upon the obverse side of this developmental picture, we must recognize the fact, that from the moment of the very first respiration at birth, one of the most

potent influences upon which this jaw expansion and development depend is the physiologic action of correct respiration; thus we have established backward and forward an interrelation of growth so evenly balanced that it would naturally seem to preclude its being unusually important to any one division more than the other.

Another interesting feature in the embryonic stages is noticed in the large size of the tongue in proportion to the jaws. This is important in its influence upon the maxillary ridges and is of great significance in calling attention to the fact, that being so out of proportion in size if the growth of the jaws be arrested, and consequently failing to give space during the early childhood, which will enable free use of the tongue in speech, such children learn to speak with great difficulty, if at all, or, as might be expected, are reluctant to make the unusual effort required of them in learning to form certain words. Thus the brain cells, directing this action, do not develop, and in the course of time such children come to be considered defective, and ultimately are really so, because the speech centers are arrested in their natural progress. Undoubtedly many of these might have been at least approximately normal if this condition had been corrected at a sufficiently early date.

In the series of skulls shown, which were collected by Professor Prentiss of the State University of Iowa, one at about term and the others at different stages, until approximately the sixth year, viewed from front, profile and their basal aspects, we note the same progressive changes begun in embryo; becoming even more and more marked as growth takes place, and the modifications due to eruption of the deciduous teeth become apparent, and these in turn are affected by the development of the germs of the permanent set, until governed by the eruption of the first permanent molar, which Bogue has so ably called attention to as being one of the chief determining factors in the establishment of correct or incorrect occlusion of the permanent teeth.

With cases such as figures 4 and 5, where the hard palate is perfect, with deformity of the lip on one side, the fissure

extending through the alveolar ridge, there are both deflection of the nose and in the absence of yielding through the line of the fissure, with consequent widening such as usually marks this form of cases, also a forward projection of the premaxillæ, brought about through increased growth of bone, which takes place in the maxilla just behind the alveolar ridge.

In precisely the same way, when double harelip exists, as in figure 6, the projection of the premaxilla and the deformity of the vomer are accomplished by unusual growth of maxillary and other bone structures, caused by adverse muscular action. Thus we find that the result of any of these defects brings about, not only a symmetrical form, but change in actual bone growth as well, and while nonsurgical corrective measures applied to readjustment of form may be necessary and sufficient in many cases, when actual changes in bone growth has been brought about and there is consequently either more or less than normal bone structure in a region, measures must be adopted upon the one hand to cause an increased growth, or, upon the other, to accomplish the removal of superfluous bone before natural conditions can be resumed.

A rather striking example of this is shown in illustrations figures 7, 8, 9, 10. Both individuals were burnt at three years of age. Each was left to grow up with tension of scar tissue contracting muscles in the same region. In one case the muscular tension happened to be such as to cause elongation of the jaw, to correct the deformity of which a considerable portion was resected. In the other, muscular action stopped jaw growth, and in order to give the appearance of a mental process the soft tissue had to be molded to produce this effect.

If our line of reason and illustration have been sufficiently clear, it should be apparent that any influence which can affect intrauterine growth, and this includes arrest of development from any cause, be it hereditary, metabolic, incidental or accidental, can directly bring about or predispose the malformations of nose and mouth.

The result of adverse muscular action may be apparent at the time of birth. With the beginning of extrauterine influences all the conditions of the physiologic action of each or all parts concerned become active in determining normal or abnormal results. Whether adenoids and enlarged tonsils be the result of an already preexisting tendency to irregular cell development and asymmetric form growth in the individual, or due to restricted respiratory action or to some other influence, it is perfectly evident that with obstructive influence activity against natural respiration, correct nasal and oral form would be practically impossible.

To summarize the results of our investigations this far, we admit all of the etiologic factors that have been commonly, variously and individually urged by writers with the statement that any interference with continuous and complete embryonic growth will manifest itself in imperfect form, directly due to the arrested development and in asymmetrical exaggerations thereof, including alteration in both form and structure, by the imperfect physiologic action of the immediately affected and surrounding parts.

Second. After birth, any abnormal muscular activity, whether due to the unusual stress of habit, accident or other cause, will make its influence manifest in distortion of the form of the growing parts.

Third. With obstruction of the upper air passages complete symmetrical form of the palate and upper maxillary arch cannot as a rule be expected.

Conversely, any factor which tends to contract the form of the palate in such manner as to bring about crowded and high arched condition of the palatal vault, with the usually attendant saddle-shaped, narrow dental arch, must in greater or less degree tend toward contracted nares, deviated nasal septa and commonly associated nasal defects. For these reasons it is manifest that adenoids and enlarged tonsils, whether first or second in etiologic succession, are always and invariably contributing factors of first importance. The propriety of their removal as a corrective measure is obvious. We, therefore, wave discussion of the question of etiologic precedence,

since all treatment must resolve iself into procuring increased space for the purpose of more complete physiologic action in respiration and also room for development in the dental region.

As I have made it clear in previous writings upon this subect, the appliance I use for separating the maxillæ is merely an adaptation of well known orthodontic instruments and principles for this purpose, and the space that appears between the central incisors, which is indicative of division through the median maxillary suture, has been frequently noticed by many dentists and orthodontists, who have had it occur accidentally in the course of their treatment.

My only claim for originality lies, therefore, in the application of these principles in this way for the specific purpose of producing maxillary separation in order that widening of the nares and correction of nasal defects might be the direct result. It is undoubtedly true, that having thus obtained the increased size in the dental arch through expansion, the proper space allowed enables nature to correct many dental irregularities in considerable measure without further interference. In all cases, unless locked in lingual, labial or buccal occlusion, or for some other reason held in malposition by forces or factors which cannot thus be overcome, the natural tendency of all teeth is to seek their rightful positions in the dental arch and to assume proper occlusal relations.

I have previously estimated that about 75 per cent of the orthodontia now considered as being required would be unnecessary if this simple procedure were performed at a sufficiently early date. Others have made somewhat higher estimates. Notwithstanding all this, I wish it to be clearly understood that this method is in nowise brought forward as a complete substitute for well known orthodontic systems, because the principles and methods of orthodontia are often necessarily employed to complete what has been accomplished by maxillary separation in order that the improved condition thus secured may be made permanent by correct occlusion of the teeth in both jaws. At the same time it is necessary to emphasize the fact that the movement of the teeth under

the kind of pressure exerted in the ordinary course of tooth regulation by orthodontists and dentists will not give the increased intranasal space or make possible the correction of nasal defects, in anything like the same degree, even in young children, and in adult cases it is extremely doubtful if any improvement of sufficient value to improve marked deflection of the septum could be secured in any other way than by direct pressure which will cause separation of the maxillary bones.

The reasons for this statement are exceedingly simple. The principles of the various orthodontic systems now in vogue require pressure which will cause a gradual movement of the teeth. The result of pressure so exerted is to cause bone absorption. This Talbot has amply proven.

There are many reasons why this is advantageous when applied to the correction of dental irregularities, but in order to carry the effect into the higher region of the nose, the less movement of the teeth through the alveolar structures takes place, the better the result will be, in so far as widening of the nares is concerned. It is because of this fact that more or less disappointment in results has occurred in some instances, when rhinologists have referred these cases to orthodontists and dentists, for, although the teeth in the course of time may have been beautifully straightened and symmetrical arches secured, the nasal improvement has not been such as it might have been, had the process of direct pressure here recommended been applied and a positive result obtained within a period of approximately two weeks.

Our practical illustrations of the truth of this statement are almost unlimited and could be multiplied by descriptions of cases in practice that have been cared for during the past few years in almost any number that might be desired. The pathologic explanation seems to be established with equal certainty when we consider Talbot's experiments on dogs and my own results of expansion upon green skulls, both of which are here given.

Talbot's experiments with regulating appliances in the mouth of dogs were as follows: The screws, which were given one-fourth, one-half and one full turn every evening, were 60 threads to the inch. The teeth of three dogs were moved 1/240, 1/120 and 1/60 of an inch daily, respectively.

The process in which the screw was turned one-fourth and one-half turn each day was continued for seven days; the one in which the screw was turned one full turn was continued for two weeks. The object was to set up pathologic changes in the alveolar process similar to those produced in the human mouth. Talbot's findings, proven by microscopic sections of jaws of the dogs thus treated, show beyond question that movement under these conditions is effected by the ordinary processes of bone absorption.

By reason of the surgical division, to which my practice is limited, through constant observation of the marked nasal and maxillary deformities, which occur in harelip and cleft palate cases, it has been impressed upon my mind that there are some principles having a direct bearing upon our subject, the rationale of which in nasomaxillary developmental relation can be more accurately observed in those cases than in the course of normal growth, because through the opening in the palate and in the lip the form of the nasal septums affected by normal conditions can be directly studied with the entire field in view. The resulting changes in form and structure of both osseous and cartilaginous nasal structures by adverse muscular action can also be plainly seen.

Although conditions may in many respects be radically different when there are no fissures through the palate or lip, the factors which play a part in determining both intra- and extranasal form results, though modified in degree, are in effect precisely the same.

The study of the illustration of a few of these cases and the results of their correction, with description of the principles which guided the method of their treatment, would seem to be advisable in order to lay a foundation, upon which the method of explanation of the method of correction, which is the subject of this discussion, must depend, since it is through the study of those cases and effects that we have been led to the adoption of this kind of treatment.

A few conditions in harelip and cleft palate cases appear to be invariable, notably in single fissure through both hard and soft palates. When the division extends completely through the naris on one side, we find the premaxilla attached to the opposite side, and through want of proper muscular control, by reason of the lip being open, in all cases

projects forward and is turned in the direction of the side to which it is attached. The maxilla upon the opposite side is drawn away from its fellow and backward through want of muscular tension in a forward direction, thus widening the fissure. The nasal septum in these cases is attached to the side upon which the premaxillary portion is united. The cartilaginous portion of the nose is always deflected to that side, also the ala upon the opposite side is flattened and more or less spread out, because its external angle is joined to one side, while the dividing cartilage is adherent to the other. In some cases the hard palate in the course of its formation extends upon each side of the fissure to a point where it forms a complete and clearly outlined border, from which upon one side the nasal septum extends more or less directly upward, with a noticeable though not severely marked bulging in the direction of the open side, upon which, of course, there is no floor to the naris.

In other cases of practically the same type the septum is so bulged as to appear to extend out upon the surface of the palate (see Fig. 11) until the clearly outlined border which should mark the line of demarkation between palatal and nasal tissues has become almost obliterated.

In double harelip cases, (see illustration Fig. 12, 13) the premaxilla is completely separated from attachment to the upper maxilla upon each side, therefore no continuous action between the labial and facial muscles is possible. In such cases there is an elongation of the vomer and of the lower border of the triangular cartridge, which causes the projection forward and typical deformity of the premaxilla and nose. The anterior portion of the upper lip, which is attached to the premaxilla, also fails to assume its proper size and shape. This defect is so marked in many cases as to give the appearance of lip and nose forming a straight line in a forward and upward direction. When there is complete fissure upon one side, with incomplete division upon the other, there is always a deflection of the projecting premaxilla which carries with it the attached nasal structures toward the side of the wider fissure. Figures 14 and 15 show the effect of failure to recognize these principles in surgical operation and the possibilities of later correction by surgical restoration

through observation of natural conditions. This is not an exaggerated example, for I have many such.

Illustration No. 16 is of particular interest in proving the possibility of complete fissure throughout the central median division in development of the face.

The infant here shown had not only fissure through the palate and central portion of the lip, but completely upward through the nose as well, the nasal septum being completely separated into two distinct divisions. A larger tumor, evidently a cyst, containing cerebrospinal fluid, completely filled the central portion of the mouth. The character of the fluid was not actually demonstrated, for fear of fatal result, but the anatomic form in maldevelopment was established beyond question in the operations which were performed to overcome the deformity.

I believe the defects to be accounted for by this double development of the nasal septum occur more often than is commonly realized. Not only is the effect noticeable in bulging or buckling on opposite sides of the same septum, but I have recently had under my care an infant, born with double harelip and cleft palate, in which there was a continuous line of attachment from the nasal septum to the maxillary division of the palate upon each side, the entire central portion being open and apparently not connected with the nares. This condition was discovered in an effort to pass a catheter through the nose for the purpose of continuing anesthesia during the operation for closure of the palate. The catheter, when inserted and passed through the nose, appeared quite close to the eustachian opening, and, very much to our surprise, could not be passed directly through into the wide open space in the center of the palate.

The best description of the double development of the anatomic parts of the nasal septum, the nasal processes, the vomer, the vertical plate of the ethmoid, the upper maxillary, the triangular cartilage and its caudal prolongation and the relation of the premaxillary wings, as affected by developing tooth germs, reflecting upon the form of the septum, has been given with supporting evidence from the anatomic room in an exceedingly complete series of illustrations by Harris Peyton Mosher, Boston, who states that "The septum at birth is almost cartilage. The only bony parts are the vomer and the

two premaxillæ and their processes. The vomer consists of two leaves of thin bone, which are united below, but are open and flaring above. This formation is a relic of its double origin, evidences of which the vomer never entirely loses. The premaxillary wings spring from the posterior half of the upper face of the premaxillæ. In the groove which they form rests the tip of the vomer. Two other processes spring from the superior surface of the premaxillæ, namely, the nasal spines. These again make a slight gutter, into which in its turn fits the tip of the premaxillary wings and the tip of the premaxillary wings. The tip of the vomer rests in the gutter of the premaxillary wings, and the tip of the premaxillary wings rests in the gutter of the nasal spines, like the arrangements of the sections of the old-fashioned wooden drain. The upper border of the adult vomer is gutter shaped, like the vomer at birth, the gutter not being so deep.

"A large number of deviations of the septum are caused by asymmetry in the development of the bones which make the hard palate. This inequality of the development is usually due to delayed or irregular eruption of the incisor teeth, especially of the middle incisor. When the eruption of one central incisor is sufficiently belated it causes a deformity or hypertrophy of the maxillary wing above it. This distorts the retaining groove made by the premaxillary wings. As a result, the septum slips from its bed in the vomer, and the grooves made by the two leaves of the vomer spread open, one leaf on the side of the vomer disappearing. This produces a spur along the upper edge of the vomer. As the cartilaginous part of the septum slips from its bed the lower edge curls upward and outward, so that its lowest portion becomes concave. Higher up on the septum this concavity gives place to a compensatory convexity. The convexity generally is towards the spur. On the side of the delayed tooth a short basal spur indicates the enlarged premaxillary wing. The upper wisdom tooth may deform the septum posteriorly. This asymmetry shows in the nasal notches anteriorly and in the choanæ posteriorly and in the mouth. Abundant dissecting room findings prove that deviations so started may extend far backward on the septum and become obstructive."

It is interesting to note that this evidently painstaking and exhaustive study of embryonic and later anatomic study, sup-

ported by evidence from the dissecting room, coincides so perfectly with the results of our study of maldevelopment and clinical experience in this region. With Mosher's illustrations and descriptions before one, there can no longer be a doubt of the practical corrective efficiency of a method which would separate the halves of these developing parts sufficiently to supply space for their assumption of the normal form, which had been denied them through insufficient room for proper development. The elaboration of the gutter form of the premaxillary wings and vomer, and other evidence submitted showing that with deviations of the septum the first tendency is to slip out of the trough which forms its natural resting place, makes plain the reason why straightening of the septum, even in adult patients, takes place in such marked degree when the maxillary bones are separated, a fact that has been proven over and over again in our clinical experience, but for which we have been somewhat hesitant about claiming to such an extent, as our result seemed to warrant, for we may now assume that the separation must necessarily reestablish the gutter form and allow the natural resilient septum to seek its proper resting place.

Obviously, the simple and most natural method of correction must lie, in so far as possible, in the application of force, which will directly overcome not only the first causes, but the secondary results as well.

The appliance that I use is constructed by attaching metal bands which fit the cuspids and one molar tooth upon each side of the mouth. These are attached by rigid metal bars which rest against the lingual sides of all intervening teeth. To these are attached a tube upon one side, into which fits a threaded bar nut adusted to fit. These are so arranged as to make direct pressure across the palate at the point of greatest constriction when the nut is turned. Force thus applied is distributed against all of the teeth upon each side of the dental arch, and by turning the nut twice daily, continuing each time until firm pressure is felt, but no pain whatever experienced, the maxillæ can be separated through the median suture of the palate and division between the central teeth. When this occurs, the incisor teeth are moved apart, and, since the appliance does not touch them in any way, the only explanation is that the bones in which

their roots are embedded have been moved away from each other. Both intra- and extranasal measurements prove that in this movement the nasal bones and other attached parts have also been included, and the result is that there is a direct and immediate increase of space within the nares. To prove this definitely, similar appliances were adjusted to green skulls, an experiment which was made possible through the courtesy of Dr. Lea W. Dean of the State University of Iowa. Its result is shown in figures 17 and 18, in which the parted sutures can be plainly noticed, with increase in actual measurement of one-eighth of an inch across the base of the nose and one-sixteenth of an inch across the upper third.

The following cases, though previously reported, are fair examples of the usual clinical results, and are submitted as additional evidence of the truth of our theoretical foundation and the practical efficiency of this method of treatment.

Figure 19 shows a young man, aged 29, whose nose was injured by a baseball in early youth. Dr. Nelson M. Black, by whom the patient was refered to me, found the septum buckled in such a manner as to give almost complete stenosis of one naris, the turbinal bodies much enlarged, and hypertrophic conditions generally marked. The patient was greatly troubled by attacks of sneezing when he bent his head downward. The appliance was adjusted April 6, 1908. Within two weeks the space between the central incisors appeared as shown in figure 20. Actual enlargement of the nares was confirmed on examination by Dr. Black, and by the improved breathing experienced on the part of the patient himself, thus proving that even at this patient's age the desired result had been quickly accomplished. Most of the time the patient, who resides in another city, was at a distance from me, and had the appliance turned by one of the members of his family.

Figure 21 gives the actual measurement with a millimeter gauge of two casts of the mouth of a lad of thirteen years, one taken before the arch was separated, the other at the time when the division through the central incisor was evident, and his rhinologist, Dr. J. A. Bach, of Milwaukee, reported sufficient improvement of his nasal condition. This is a fair example of the approximate increase in width of the palate that is required in such cases.

To these might be added a long list of other patients who

have received the same treatment with precisely the same result in my practice during the past few years, if repetition by citation of other cases were either necessary or advisable. All these cases show deviation of the nose from the central facial line, an imaginary, though clinically a very useful, line, to which I have previously called attention, taken through center of forehead, tip of nose and center of chin. Deviation from this line, one way or another, is a fairly certain indication of perverted nasal and maxillary growth, leading almost invariably to pathologic nasal conditions.

Especially among growing children treated by this method has there been marked physical improvement, tendency to growth in height, as well as general development and increase in weight. Many of these had previously been unable to attend school regularly because of the tendency to nose, throat and bronchial affections. Nervousness was almost invariably very greatly relieved, and this, it is believed, for two reasons. First, the well understood results from the improvement in breathing apparatus, with general healthfulness to be expected from better aeration and freedom from diseased nasal secretions; and, second, the relief of that condition to which Kiernan has called attention, caused by crowding together of the dental arches, with tendency to nerve irritation. This condition quite frequently manifests itself, not only in increased nervousness of a general character, but also in the development of neurotic tendencies leading to chorea, epilepsy and other similar affections, which, in some instances at least, might perhaps have been averted if these patients could have been tided over critical periods in their development. This has been recognized by Dr. Talbot as one of the periods of stress. Certainly it is a curious fact that even with the disadvantage of having the appliance in their mouths and the bar across the palate, children who are subject to such pathologic conditions almost immediately become less nervous, have increased appetites, and general development goes forward almost from the very first few days after pressure has begun to be exerted.

I can not help feeling that this treatment can be made a very great factor in safeguarding against tuberculosis. It is so easily accomplished and the results are so greatly beneficial that it should be applied to hundreds and thousands of

growing children, who are unquestionably more susceptible to pneumonia and bronchial affections because of imperfect breathing. It offers a possibility of relief which is especially important on account of the fact that such defects are well known to be on the increase, arrested development in the maxillary region being more marked in each generation under the conditions of our so-called civilization.

In final proof of the truth of all the foregoing theoretical and clinical conclusions I am privileged, through the courtesy of Dr. Lee W. Dean of the State University of Iowa, to submit the following record of the case of a young girl of 17, a patient of Dr. Dean's, for whom I performed maxillary separation to aid the correction of serious nasal and other defects. These measurements were made with an instrument invented by Dr. Dean for the purpose, and taken by his associate, who had no special interest in the case, and whose accuracy could in nowise be consciously or unconsciously affected by any preconceived idea or expectation. They are therefore absolutely correct.

	A.		B.		C.	
	May		Aug.		Feb.	
	28, '09.		11, '09.		18, '10.	
	R.	L.	R.	L.	R.	L.
Ant. end Inf. Turb. to Sep.	5	6	8	9	9	10
Middle of Inf. Turb. to Sep.	5	4	7	6	7	6
Post. end Inf. Turb. to Sep.	10	12	10	12	12	12
Ant. end Mid. Turb. to Sep.	2	2	2	2	4	4
Mid. of Mid. Turb. to Sep.	1	2	2	2	2	4

Having thus fully demonstrated the practicability of the improvement of nasal deformities and attendant disease by separating the maxillary bones and directly increasing the size of the nares, it only remains for us to prove that constriction or arrest of growth in width across the palate could cause deviated septum, contracted nares, or even complete nasal stenosis.

This I am able to do through the courtesy of Parke-Davis, in whose Biological and Research Department I was permitted to do some original work on puppies, and the able assistance of Dr. Ferry and his associates in the laboratory. Several pups eight weeks old were operated upon by passing a wire through the maxillæ from a point above the roots of the teeth upon one side above the palate and out at a corresponding

point upon the opposite side. The palate was compressed sufficiently to force the upper teeth inside or in lingual occlusion with the lowers, so that the upper and lower jaws of these puppies were placed in about the same occlusal relation that exists with growing children whose bicuspid teeth meet the corresponding lower teeth in lingual (inside) instead of buccal (outside) or normal occlusion. Not nearly so much force in compression was used as would be necessary to close a case of palate fissure according to the method which was formerly widely practiced upon infants with cleft palate. The purpose was to reproduce as nearly as possible the maxillary condition of typical cases of mouth-breathing children. One pup was kept without operation as a control, and all were allowed to develop until they reached the age of six months, which, it was estimated, would approximately correspond to the age of a child of eight or nine years old. The puppies were then killed, the heads frozen, and sections cut through the nose and upper jaws at short intervals. The result is shown in Fig. 22, a, b, c, d, e, and Fig. 23, a, b, c, d, e. Marked difference between the nares will be noted throughout both series, but the section marked c in each is exactly at the point where compression was made. The almost complete stenosis in Fig. 23 contrasting quite strongly with the same section in Fig. 22.

The laboratory record shows that all of the puppies in this litter, under the same care and with the same food for a time thrived equally well, and their growth was about the same. During the latter portion of the period, when the effect of the compression upon nasal growth became apparent, the control dog continued to grow and thrive, but those operated upon became emaciated. One died shortly before the expiration of the trial period. The one shown in the illustration was a mere mass of skin and bone. The remaining puppy showed marked congestion of the lungs. Experiments conducted in the Parke-Davis laboratory by the late Dr. Willis S. Anderson, of Detroit, who produced partial stenosis in dogs by suturing the external nasal openings, and by introduction of packings in several ways, demonstrated, that while the mucous membrane of the bronchi of dogs in good health is practically immune to pathogenic microorganisms, when their breathing is affected, they become highly susceptible to every sort of

infection in this region. Such dogs become almost entirely hairless, and the puppies of such mothers in some instances lost their hair also.

As is well known, children who are mouth breathers because of adenoids and enlarged tonsils, arrested or perverted nasal development, are frequent sufferers from coughs, colds and other evidences of infectious processes in this region. The same is true with older persons in corresponding degree.

Having thus been able to cause deviated nasal septum and contracted nares by arresting maxillary development and to correct these deformities and their attendant ills by maxillary separation, it seems fair to assume that our case is complete.

Figure 1. Section through the head of a human embryo at approximately the fifth to seventh week, showing fissure in the premaxillary and palatal region united.

Figure 2. Section through the head of a human embryo at approximately the eleventh to twelfth week, with palate completely united. Progressive enlargement of the nares, bone and tooth development indicated.

Figure 3. Section through the head of a human embryo at approximately the twentieth week, shows developing teeth high up at each side of the now much enlarged nares. Double development of the nasal septum. The tongue large and much in advance of the lower jaw, in which tooth follicles are now clearly outlined.

Figure 4. Little girl of six years, with harelip, fissure extending through the alveolar ridge only, shows deflection of the nasal septum and triangular cartilage of the nose, flattening of the left cartilaginous wing, and a permanently fixed deformity of the premaxillae.

Figure 5. The same girl after forcible correction of the deformity and closure of the lip.

FIGURE 1. Little girl [illegible] through the alveolar ridge [illegible] [illegible]

FIGURE 2. The same girl after forcible correction of the deformity and closure of the lip.

Figure 6. A typical case of double harelip and cleft palate showing characteristic deformity of the nose and palate.

Figure 7. Man of 22, burned at three years old. Scar tissue in this case caused elongation of the lower jaw so that the upper exposed teeth occluded with lower molars.

Figure 8. Same individual shown in Fig. 7, after operation. The unusual thickness in this case was taken advantage of to carve out a chin after removal of the teeth and external plate. The soft tissues were readjusted upon the newly formed bone structure.

[illegible]

Figure [illegible]. Same individual shown in Fig. 7, after [illegible] thickness in this case was taken advantage of to [illegible] after removal of the teeth and external [illegible] The soft tissues were [illegible] upon the newly formed bone.

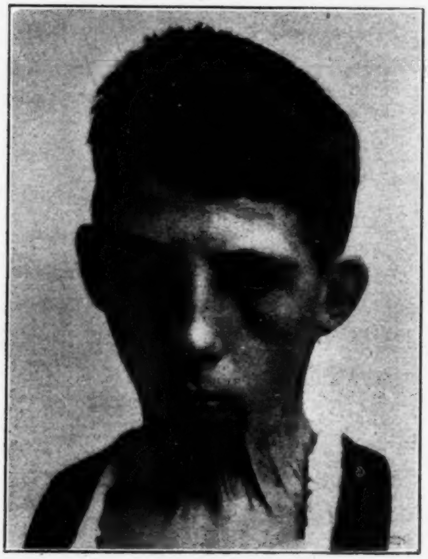

Figure 9. Boy of 14, burnt at about three years old. In this case the effect of the tension of scar tissue was exactly opposite to the case shown in Fig. 7. The growth of the jaw was almost entirely prevented.

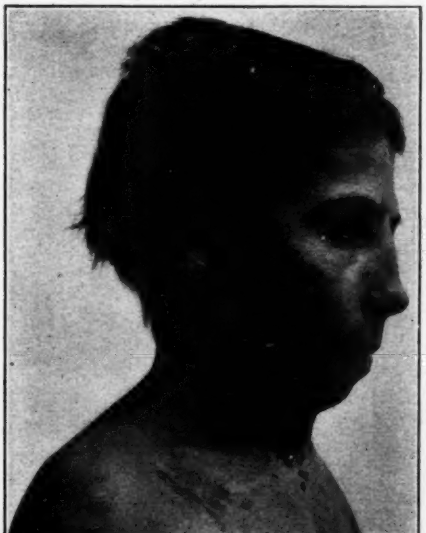

Figure 10. The same boy after operation. By removal of the scar tissue covering the skin grafts and moulding a chin out of soft tissue to supply the deficiency in the region of the mental process.

[illegible]

[illegible] The same boy after operation. By removal of the [illegible] and moulding a thin bed of [illegible] to supply the deficiency in the region of the mental [illegible]

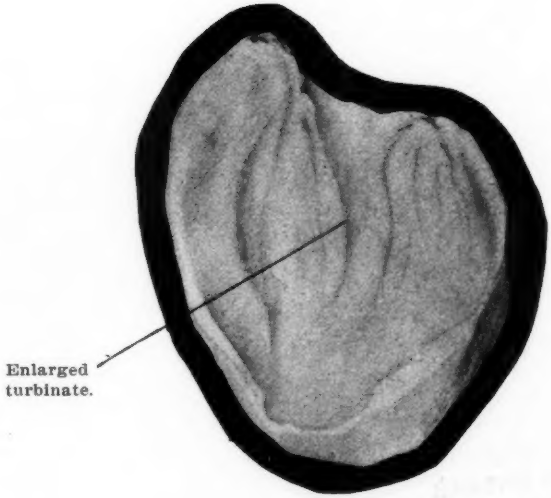

Figure 11. Cast of mouth of infant with harelip and cleft palate. The septum of the right side is so bent and extended toward the left that a line of demarcation between septum and palate on the right side is almost obliterated.

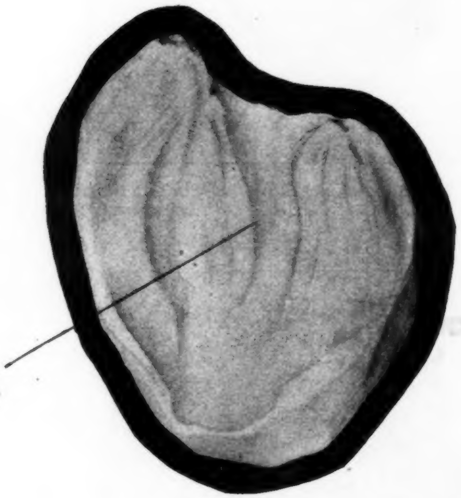

Figure 11. Cast of mouth of infant with harelip and cleft palate. The septum of the right side is so bent and extended toward the left that a line of demarcation between septum and palate on the right side is almost obliterated.

Figure 12. Baby with double harelip and cleft palate showing typical deformity.

Figure 13. The same baby shown in Fig. 12 after operation. In the case of this baby the steps of treatment were: (a) First, correction of deformity with adhesive strips across the face. (b) Closure of the lip and adjustment of the cartilaginous wings of the alae of the nose. (c) Closure of the hard palate two or three months later. (d) Completion of the case by closure of the soft palate. The child has normal development of the mouth, teeth erupted in proper position and a full, flexible, soft palate as well as symmetrical external features.

Figure 14. A young man whose lip was operated upon in early infancy without due consideration of developmental principles.

Figure 15. The same individual shown in Fig. 14 after reoperation upon the lip and readjustment of the deformed parts.

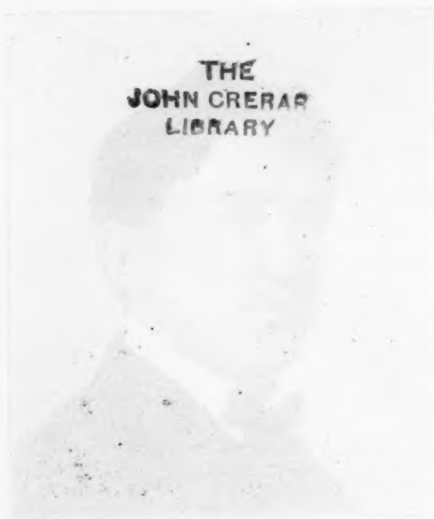

Figure 16. Baby with harelip and cleft palate having also a groove through, dividing the nose into two parts with one-half of the septum upon each side, this double development evidently extending completely through to the cranial cavity.

Figure 17. Skull with appliance in position and median suture separated.

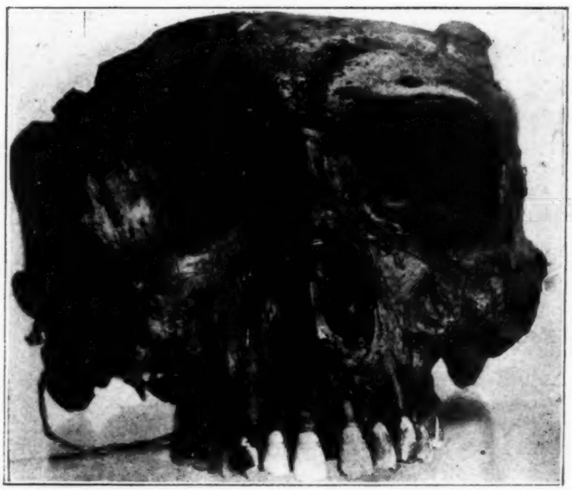

Figure 18. Another view of the same skull shown in No. 17. The division between the central incisors and separation of the suture up to the nose is shown.

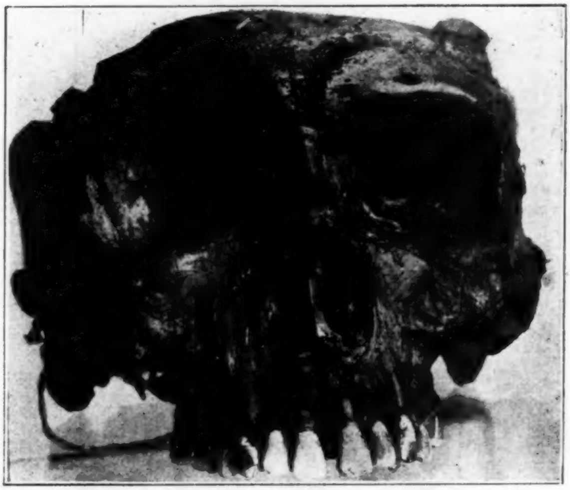

Figure 18. Another view of the same skull shown in No. 17. The division between the central incisors and separation of the suture up to the nose is shown.

Figure 19. Young man, age 19, with nose injured in early youth. Badly buckled septum and almost complete stenosis of one naris.

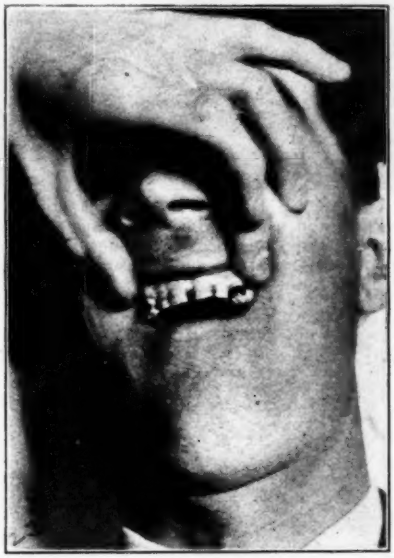

Figure 20. Same young man about ten days later. Separation between the central incisors confirmed by intranasal examination, which disclosed enlargement in this region, evidence maxillary separation.

Figure 21. Casts of the mouth of a boy at 14, before and after expansion. The space between the central incisors closes itself in the course of time without operative influence.

[illegible]

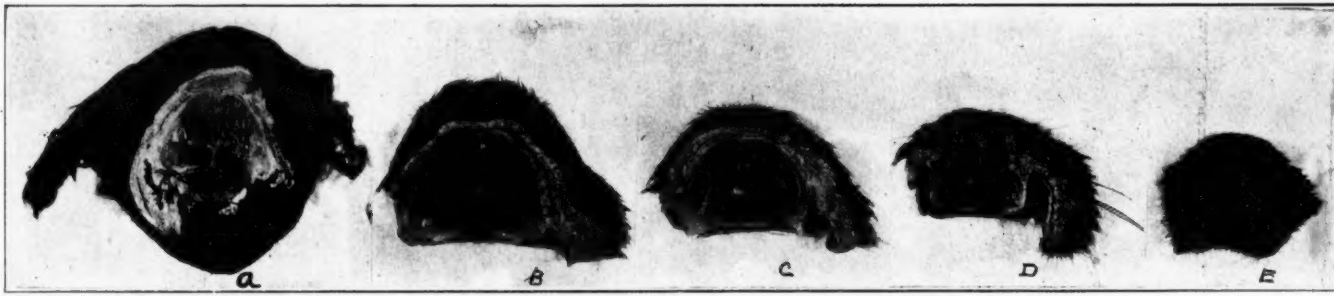

Figure 22. The same age as Fig. 23, upon which no operation was performed.

Figure 23. Sections of head of puppy six months old, with jaws arrested in development across the palate by wiring at eight weeks old. These sections show plainly the contracted effect upon the nares, the deviation of the nasal septum, especially the section shown in c, the point at which the wire was inserted and development arrested.

LVI.

WIDENING THE DENTAL ARCHES IN NASAL STENOSIS; ITS RESULTS AND POSSIBILITIES.

By Nelson M. Black, M. D.,

Milwaukee.

SEPTAL DEFLECTIONS.

Practically all rhinologists ascribe to irregularities of the upper maxilla an important place among the etiologic factors of septal deformities; still very few select correction of these irregularities as a means of correcting the septal deviations.

Of the rhinologists who have had ocular proof of the results by spreading the dental arch in what seemed to be typical cases of deflected septa, a few have become converts; some have admitted its possibilities in selected cases; while others have said operative procedures upon the deformed septum itself was the only method.

The results obtained in the cases referred to Dr. G. V. I. Brown have without exception shown marked improvement; naturally, some more than others, for reasons to be mentioned later.

Dr. D. B. Kyle[1] rightly says that of the many operations for the correction of septal deflections, each was suggested by its author for a particular variety of deflection, and that much discussion and confusion has been caused by the fact that other operators adopt the methods for varieties of deflection to which they are not adapted. The results being unsatisfactory, the method is condemned.

The varieties of septal deflection are infinite, and, although some authors attempt a classification, no two are alike. From my understanding, the same may be said of dental and maxillary irregularities. As a result, no definite rules can be laid down as to treatment, each case being a law unto itself.

OBJECTS TO BE OBTAINED IN CORRECTING SEPTAL DEFLECTIONS.

The objects to be obtained in treatment of septal deflections are: First, to establish free nasal breathing; second, to restore the septum to the median line with its surface as smooth and even as possible; third, to equalize the space on either side of the septum; fourth, to leave the mucous covering of the nasal interior as little injured as possible, so that its functions may not be impaired.

The first thought that comes to one on looking into a nose having a septum with a marked deflection is that more space is needed, and that something must be removed to obtain this. There is no doubt that there is seemingly superfluous tissue in the largest percentage of these cases, when compared to the nasal space in which they are found, but the fact that the nasal space is much smaller than it should be is, as a rule, not taken into consideration.

The removal of tissue, such as turbinates and thickened portions of the septum in overcrowded nares, is beneficial, but does not correct the deformity of the septum. In many instances, however, the removal of too much tissue (which is a fault with many operators) is a real source of danger. It would seem far better to increase the size of the nasal fossæ first, and then proceed to the removal of any superfluous tissue, should it be found necessary.

This can be accomplished, but, so far as my knowledge goes, only by widening the arch of the superior maxilla. This procedure, to be effective in enlarging the base of the nares, must be essentially different fom the ordinary expansion for the regulation of the teeth in abnormal position.

Several dentists, whom patients have selected to do this work, have attempted to widen the upper maxilla by a slow, torturing process of expansion, which exhausted the patience of the individual long before the desired results were accomplished.

Dr. G. V. I. Brown[2] accomplished this result 11 years ago in the case which first started my investigations along this line. He is the only man with whom I so far have personally come in contact who succeeds in obtaining the results desired and absolutely without discomfort to the patient and in an incredibly short time. We have differed to a certain extent as to

how the result is brought about. Dr. Brown believes it is produced entirely by separation of the median palatal suture, which is manifested by the increased space between the middle incisors.

My theory is that in addition to this separation there is a real lowering of the vault, the result of an outward tilting of the alveoli. I can not see how the septum could be so materially straightened, which is the case in practically every instance, unless the vault is lowered and allows the septum to straighten by its own resiliency. However, when one considers the very small amount of vertical shortening found in a badly deflected septum, it is necessary to realize that but little space is required within which it may become straight. The ever-present resiliency and elasticity of a deviated septum will tend to cause straightening if the pressure at the base of the septum is relieved.

This relief of pressure occurs when the palatal suture is opened in the process of widening the superior maxilla, as evidenced by separation of the incisors. There is, however, another class of arches with deviated septa where beneficial results are obtained, in which some other movement must take place, as in this class there is no visible separation of the incisors.

What does take place must be either a separation of the median suture back of the premaxilla, or else (and Dr. Brown says he is afraid he must concede to the latter) an actual lowering of the vault occurs. In either case 2 or 3 mm. increase of vertical space would result, which is all the septum requires within which to straighten itself.

WHY THE OLDER OPERATIONS WERE NOT EFFECTIVE IN SEPTAL DEFORMITIES WITH DENTAL IRREGULARITIES.

Before the introduction of the submucous resection for deflected septa the various operative procedures gave but indifferent results, and in many cases there was a return of the deformity. This was due largely to the fact that the main etiologic cause remained—that is, some dental or jaw irregularity—with lessened resistance in the operated septum, the result being a consequent tendency for the deformity to return. There was no increase in width of the nasal fossæ; the trans-

mission of the force of mastication through the irregular superior maxilla and septum helped to maintain the deformity and to keep up the congestion in the nose; the result being that the turbinal bodies did not tend to diminish in size. This latter feature is also active in the nose after submucous resection, as the dental irregularity still remains.

THE AGE AT WHICH TO WIDEN THE DENTAL ARCH FOR DEFORMED SEPTA ACCOMPANIED BY DENTAL IRREGULARITIES.

The earliest deflected septum which has been reported is by Bishop, in a child of five years and nine months. Most authorities state that its occurrence is rare under six or seven years of age.

Dr. Kyle[1] referring to mouth breathing and its resultant developmental deformities, says that unless perfect nasal breathing is established early in life—that is, before the fifth or sixth year, or not later than the seventh—the bony cartilaginous framework becomes so firm that little can be done towards increasing the nasal space for breathing, and the individual will of necessity become a mouthbreather for life.

Taking the rhinologic standpoint, this statement seems reasonable, but from an orthodontal viewpoint the situation changes. Gray[3] states:

"The superior maxilla commences to ossify at a very early period, but the suture between the palate processes persist until middle life."

This being the case, the jaw may be widened at any time before this.

The first patient referred to Dr. Brown for treatment, in 1899, was 33 years of age. She obtained a perfect result.

RESULTS OF SPREADING PALATAL ARCH IN DEFLECTED SEPTA.[4]

Expansion of the maxilla relieves the pressure on the septum, which tends to straighten itself. There is an actual increase in width of the base of the nose; the breathing space being enlarged allows the nose to functionate. The volume of air being increased, the static congestion disappears, with a reduction in the size of the turbinate bodies, resulting in a further increase in nasal space.

This state of affairs should be allowed to continue until no further increase in nasal space is noticed and the turbinated bodies have decreased in size as much as possible before deciding if any tissue should be removed.

The patient is, as a rule, so well satisfied with the increased breathing space and relief from the disagreeable symptoms produced by the stenosis and congestion that he considers operative procedures in the nose unnecessary. This, however, is not always so. The removal of a spur, a portion of an hypertrophied turbinate body, is in some instances required. Very rarely have I seen cases where a submucous resection of a portion of cartilaginous part of the septum would have improved the appearance of the inside of the nose but the patients would not submit to an operation in their improved state.

RESULTS OF SPREADING THE PALATAL ARCH IN CHILDREN WITH BEGINNING NASAL STENOSIS.

The improvement, physically, in children with beginning nasal stenosis is very marked. This has been referred to by Dr. Brown,[5] i. e.: "Especially among growing children treated by this method has there been marked physical improvement, tendency to growth in height, as well as general development and increase in weight. Many of these had previously been unable to attend school regularly because of the tendency of nose, throat and bronchial affections. Nervousness was almost invariably very greatly relieved, and this, it is believed for two reasons: 1, the well understood results from the improvement in the general breathing apparatus with the general healthfulness to be expected from better aeration and freedom from diseased nasal secretions, and, 2, the relief of that condition to which Kiernan has called attention, caused by crowding together of the dental arches, with tendency to nerve irritation. This condition quite frequently manifests itself, not only in increased nervousness of a general character, but also in the development of neurotic tendencies leading to chorea, epilepsy and other similar affections, which, in some instances at least, might have been averted if these patients could have been tided over critical periods in their development. This

has been recognized by Dr. Talbot as one of the periods of stress. Certainly it is a curious fact that even with the disadvantage of having the appliance in their mouths and the bar across the palate, children who are subject to such pathologic conditions almost immediately become less nervous, have increased appetities, and general development goes forward almost from the very first few days after pressure has begun to be exerted."

RESULTS OF WIDENING THE SUPERIOR MAXILLA IN CASES OF CONSTRICTED NARES WITHOUT A PATHOLOGIC OBSTRUCTIVE. LESION IN THE NOSE.

Patients are frequently seen who say they have never breathed well through the nose. The condition found and the results obtained are well described by Dr. Dean,[6] who is quoted:

"Examination of the nose shows turbinates normal in size and structure, septum slightly deflected, as is usually the case in all noses, or markedly deviated, no exostoses, but the inferior turbinates pressing against the septum, or against the floor of the nose, or usually both, which is, of course, an abnormal condition. Adenoids may be present, but their removal does not give the usual relief. The palatal arch is constricted and, of course, there are malpositions of the teeth.

"I have patients fifty years of age with the condition above described who have never had proper nasal respiration, and in whose cases no operative procedure on the nose is indicated. In many cases like these turbinates have been entirely removed in the effort to secure breathing space. This procedure, because of its serious sequela, is never indicated except for diseased turbinates. The respiratory function of the nose may be lost by such a procedure. Even if performed, it does not give good results, as far as the breathing is concerned, because the anterior nares are so slit that in respiratory effort the alæ of the nose are brought against the septum, and nasal occlusion, in part at least, produced.

"If the nose is constricetd because of a narrowing of its walls, what is rational therapy? The only answer possible is this: The nasal walls should be separated and the cavities thus widened. This can be accomplished in only one way, and

that is by widening the palatal arch. That the nose is widened by this procedure we all know. We have all had patients who have told us that widening the arch has improved nasal respiration."

INTRANASAL MEASUREMENTS BEFORE AND AFTER WIDENING THE PALATAL ARCH IN A GREEN SKULL.[6]

The result of spreading the superior dental arch in a green skull, which Dr. Brown and I did at Dr. Dean's request, is shown in the following measurements:

1. Distance across the posterior nares just posterior to the inferior turbinates; before widening, 32 mm.; after widening, 34 mm.

2. Distance across the posterior nares just above the posterior end of the middle turbinates: before widening, 23 mm.: after widening 24.5 mm.

3. Distance from the vomer to the outer wall of the nose in the posterior nares half way from the posterior end of the inferior turbinate to the floor of the nose on the left side: before widening, 17 mm.: after widening, 18.5 mm.

4. Same measurements on the right side: before widening, 24 mm.: after widening, 24 mm.

5. Distance between the anterior attachment of the inferior turbinate in inferior portion of the middle meatus of the same point on the opposite side: before widening, 23 mm.: after widening, 25 mm.

6. Distance between vomer and inferior turbinate at narrowest part of inferior meatus, left: before widening, 6 mm.: after widening, 7 mm.

7. Same measurements on the right side: before widening. 8 mm.: after widening, 7 mm.

POSSIBILITIES OF WIDENING THE PALATAL ARCH.

Dr. Bogue[7] has outlined the possibilities that may result from the spreading of the upper maxillary arch:

"If irregularities are found among deciduous teeth, irregularities of the same nature, but still more pronounced, may always be expected in the permanent teeth which are to follow these deciduous teeth. If no perceptible irregularities of the deciduous teeth exist, and at five and one-half or six years

no separation of the deciduous incisors has taken place, we are certain that development of the arch of permanent teeth has been arrested and that there will be irregularity of the front teeth, because the permanent teeth, being larger than the deciduous teeth, need a larger arch in which to erupt."

Such an arrest of development is shown in the accompanying plate.

"The early diagnosis of cases of irregularity is readily made if one carefully notices the articulation of the deciduous molars. In normal cases the articulation is always correct; that is, the anterior cusp of the lower second deciduous molar articulates forward of the corresponding deciduous molar above, and the upper molar is astride the buccal row of cusps of the lower molars.

"Whenever these upper and lower deciduous molars articulate in any other way than this, there is sure to be irregularity in the permanent teeth if they are allowed to develop without interference. The reason for this is that the crown of the permanent teeth is embraced by the roots of the deciduous molar.

"If the first permanent molars, which erupt immediately posterior to and in contact with the second deciduous molars, are not properly articulated, it will be impossible that the other grinding teeth should be. If the upper arch is abnormally small, we may be certain that there will not be room for the anterior permanent teeth unless an enlargement of the arch is resorted to.

"If such enlargement takes place sufficiently early for the roots of the permanent teeth to be formed after their crowns shall have been drawn into correct positions, there will never be irregularities in the positions of these teeth, and it follows, of course, that they will stay where they belong.

"On the proper formation of the palatine arch and the various sinuses depends the resonance and carrying qualities of the voice, and on the accurate formation of the dental arches and the correct occlusion of the teeth depends the power of clear and distinct enunciation and the power of thorough mastication, which means insalivation. This is the first step in the digestive process important to the health and strength of the individual. It has only recently become known that impending defects of the kind here mentioned may be discov-

ered in early childhood and may be remedied while the bones are in a formative state and the teeth are in process of development.

"My conclusion is that in those cases in which a rapid spreading of the upper maxillary is applicable—that is, in which permanent teeth are sufficiently developed and erupted for the operator to be able to attach his apparatus firmly and to apply the necessary force promptly, that the method is distinctly preferable for the correction of the class of nasal stenosis that has been under discussion.

"When, however, the difficulty is recognized early enough to have it corrected by means of apparatus attached to the temporary teeth, I have found that the latter method, being to a great extent preventive, becomes distinctly preferable.

"When slight pressure is brought to bear in these regions to overcome the 'restrictions in the region of the palate and alveolar structures,' it is in the direction of normality that the pressure is applied, hence the resumption of the proper functions of the parts is soon brought about, and with the performance of function comes development, and it comes so easily in many cases that we hardly realize that the deformity has been overcome until we see before us a normal condition."

Dr. Brown has found little or no difficulty with the great majority of cases in placing the apparatus for rapid expansion upon the temporary teeth and obtaining a satisfactory result in from ten days to three weeks' time, which is a decided advantage over wearing an apparatus for seven months, as in the case of Dr. Bogue's, illustrated above. However, that is a question which the oral surgeons must decide.

The thought has occurred to all of you before now that many cases of marked septal deviation has come under your observation in which the individual seems to have a perfect occlusion and there appears to exist no dental irregularity.

The question arises as to what is the proper course to pursue.

Through the discovery by Dr. I. B. Davenport of what constitutes a normal dental arch and Dr. Bonwill's discovery of the mathematical relation existing between the width of the permanent upper incisors and the size and shape of the entire arch of the upper maxilla, we have a means of determining whether or not there does exist any dental irregularity or deformity. Dr. Hawley's application of Dr. Bonwill's formula

to orthodontia results in being given the width of one upper central incisor, the approximate shape and size of the arch to which the tooth is a member may be outlined upon paper so accurately that one may proceed to the alteration of any arch according to such a plan with absolute confidence.

Such conditions existing, it would seem best for us as rhinologists to determine whether or not we are dealing with an individual with a normal arch (which Davenport determined was a rare occurrence in civilized communities) or one in which there has been an arrest in development, before attempting any operative interference in the nose.

The question to be settled apears to be this: Given a case in which we have insufficient space for proper nasal breathing, with an arch with seemingly perfect occlusion, is it our duty and have we the right to alter the shape of the maxillæ and rearrange the occlusion to allow the nose to properly functionate?

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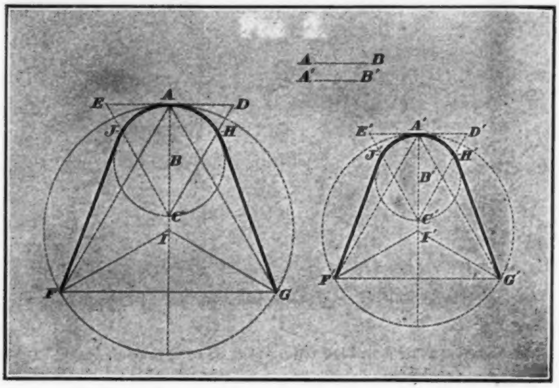


Figure 1. Mathematical drawing made from measurements of the width of three upper front teeth, showing the shapes and relative sizes of the arches constructed from the teeth of different widths. (After Bogue.)

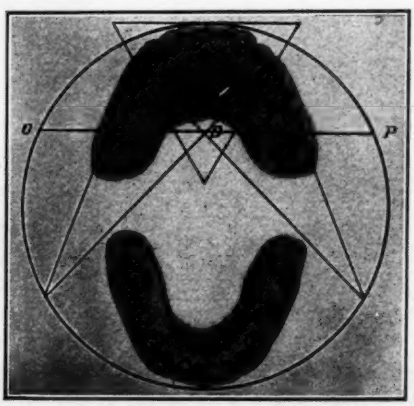


Figure 2. Mathematical drawing (see Fig. 1). Teeth have been filled in according to measurements. (After Bogue.)

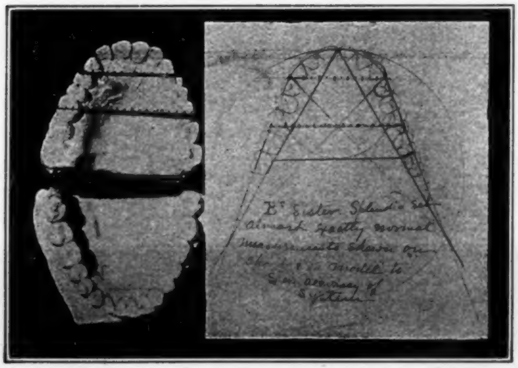


Figure 3. Model of normal teeth to show accuracy of system of measurements. (After Bogue.)

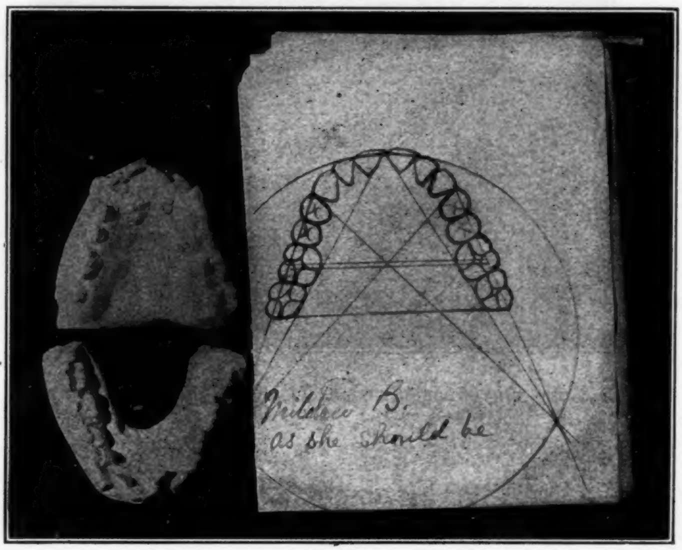


Figure 4. Model of narrow arch, with corrected shart showing teeth as they ought to be. (After Bogue.)

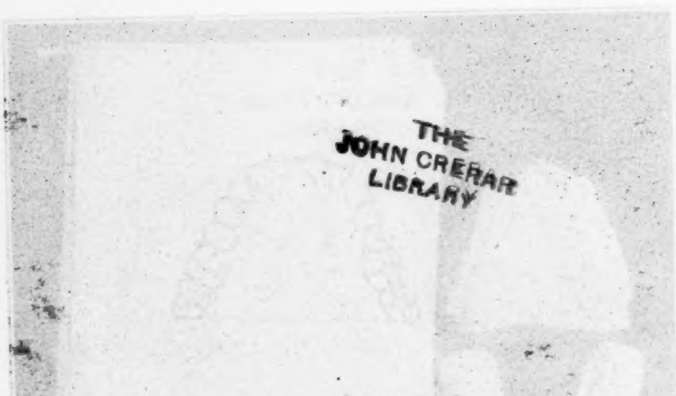
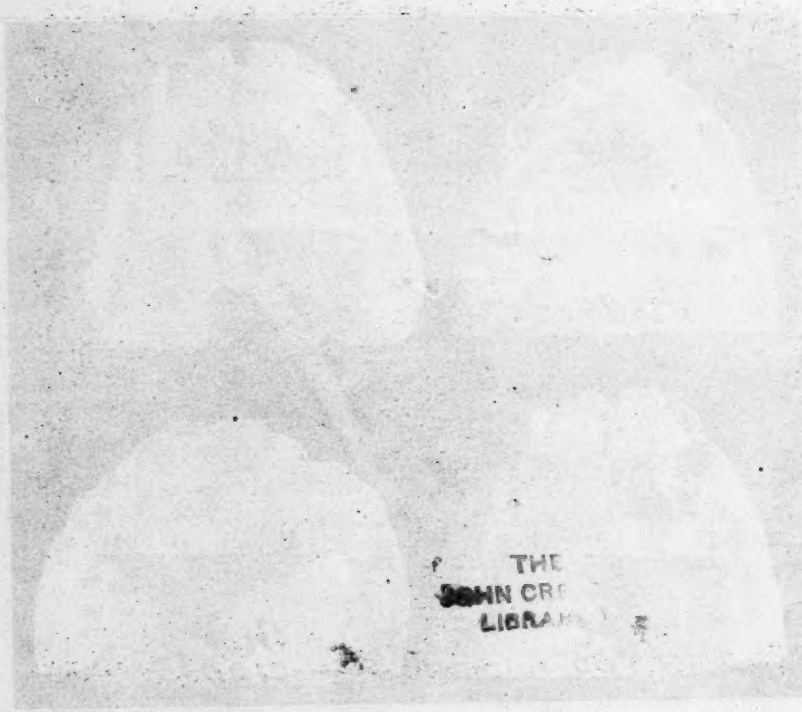


Figure 5. Showing crypts of the permanent teeth bunched in insufficient spaces in child's skull. (After Bogue.)

Figure 6. Four models of the same mouth, showing scarcely any lateral growth for three years and a lateral enlargement of 1 cm. in seven months after an expansion arch had been adjusted. (After Bogue.)



LVII.

SOME POINTS IN THE COMPARATIVE ANATOMY OF THE LARYNX IN THE ANTHROPOIDEA.

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As laryngologists we are specially interested in an organ which comparative anatomy shows has evolved from a protective mechanism placed at the entrance to the respiratory tract whose two muscles functionate as dilator and constrictor. Through slowly progressive developmental stages the simple anatomic structure requisite for this primitive physiologic function has been modified with correspondingly additional activities, till now we see a peripheral mechanism in which the primitive action is completely overshadowed by a physiologic function which may be called inter-relational, a function which has passed beyond the limits of the larynx and has reached its highest significance in the close intercourse which it renders possible between mankind. While voice is not confined to man, yet here it has reached its culminating grandeur and importance, a consummation which would appear to mark it off from all other peripheral organs. While not regarding the larynx with its functional expansion as playing a role so important in the phylogenetic history of the race as the central nervous system, yet when one notes the marked developmental progress which a study of comparative anatomy demonstrates, and when one recognizes the important part which the voice plays in the social progress of mankind, the philosophic laryngologist may well ask how much influence has this laryngeal development had on man's superiority. The more he philosophizes, the more certain he becomes that this organ, adapted for inter-relational life, is better fitted for comparative study than many which have attracted greater attention. With such a comparative history to point to and with the obvious probability that progression may still be present, one may well ask, has this development reached its culmination, and if not, along what lines is it tending? In the long and intricate path which comparative anatomy maps out in laryngeal progress, some

stages are sharply defined, but the majority blend intricately with each other. In such a comparative study there are presented some of the most interesting problems in vertebrate evolution. For instance, there are here seen such important macroscopic and microscopic differences between man and the higher mammals, especially the anthropoid apes, as to indicate along which lines development has taken place and probably is still in progress. While not emphasizing the importance of the larynx on the characteristic vocalization of the different races of mankind, yet we may note that the anthropologist seeks to find here typical distinctions between various races. Finally, we would assert that through such a study much light may be thrown on many obscure physiologic problems in voice production.

My object in this communication is to draw attention to one or two characteristic features which have recently been forced upon me. It has, within the last year, been my good fortune to be able to study macroscopically and microscopically the larynges of a Chinaman, of an orang-utan, of several macacus monkeys and of a marmoset. I was able to compare these, on the one hand, with the larynges of an adult and infant of the Caucasian race, and on the other, with the larynx of a young lion, as well as with the larynges of some of our common domestic animals, such as the dog, cat and horse.

It would be impossible as well as undesirable to give and discuss here a detailed account of such a study. My desire at this time is to present a preliminary report on some of the more interesting and important findings, and I shall confine my remarks to a comparative study in the anthropoid apes and in man of the ventricles and appendices of the larynx and of the musculature lying directly in relation to the vocal cord, namely, the thyroarytenoid. Finally, I shall discuss some physiologic considerations suggested by these anatomic findings.

In this paper the following classification of the Anthropoidea given by Beddard[1] will be used:

Sub-order.	*Family.*
Anthropoidea.	Hapalidea———Marmoset. Cebidae. Cercopithecidae-Macacus. Simiidae———Simia satyrus (orang-utan). Hominidae.

It will be noted that in the above examination examples are included from the principal families except the Cebidae.

I.—THE VENTRICULUS LARYNGIS AND ITS APPENDIX.

For the purpose of this paper we shall define the ventricle of the larynx and its appendix as follows: The ventriculus laryngis (ventricle of Morgagni) is a pocket-like diverticulum which passes lateralwards between the true and false vocal cords, undermining to a varying degree the false vocal cords; the appendix ventriculi laryngis is a blind sac which projects upwards from the ventriculus.

HOMINIDÆ.

In the white race the ventricle communicates by an oval opening with the cavity of the larynx. Its dimensions are very variable; relatively it is much larger in the male than in the female. We may take the figures of Poirier and Charpy[2] as a good average, namely, the length 20 mm. in the male and 13 mm. in the female. The height varies from 4-8 mm. The anterior extremity terminates at each side of the middle line at the angle of the thyroid, immediately beneath the insertion of the epiglottis, by the true and false vocal cords uniting, or ending slightly apart from each other, and by the floor of the ventricle passing imperceptibly into the laryngeal cavity. In the larynges I examined for comparison the floor of the ventricle was horizontal, with little or no sign of a depression or downward slope behind the true vocal cord. The lateral wall is furthest from the vocal cord in the middle or slightly nearer the arytenoid end. Anteriorly this lateral depth gradually decreases and passes medialward into the wall of the larynx. Posteriorly it ends at the border of the arytenoid without dipping either behind it or the processus vocalis.

The appendix in the white races arises by an open mouth 6-8 mm. long, lying chiefly anterior to the middle point of the larynx. It is usually described as passing into the arytenoepiglottic fold, but it would be better to say that it passes between the arytenoepiglottic fold and the thyroid cartilage. Its height is very variable, not only in individuals of the same race, but even in the same individual. Usually it runs up about 1 cm. and terminates just below the level of the upper border of the thyroid cartilage. I have occasionally seen it

reach to the level of the hyoid, and on one or two occasions to the base of the tongue. Occasionally it may be wanting on one or both sides. Its loose walls lying in folds contain glands and lymphoid tissue. A considerable amount of muscle tissue lies around the ventricle.

The most interesting anomalies found in connection with the ventricle and its appendix in the white man are:

1. A depression in the middle line anteriorly connected with each ventricle and constituting the central fossa of Merckel. The fossa in the case described by Broesicke[3] had penetrated the cartilaginous plate and formed a median ventriculus laryngis.

2. Abnormal size of the appendix. Such examples would include not only the abnormally large intralaryngeal appendices, but in addition those rarer lateral extralaryngeal sacs which pierced the hyothyroid membrane, examples of which have been described by Gruber[4] (Fig. 7) and by Sclavunos.[5] (Fig. 8.)

CHINAMAN.*

The Chinaman appeared to have been about thirty-five years of age. He was tall and well developed. From external appearances it was supposed that he was a native of Northern China. The cadaver had been injected with preserving fluid and had been for some months in a cold chamber previous to dissection. This had produced considerable shrinkage in the soft tissues; otherwise the larynx was in a good state of preservation.

The larynx, compared with a male of the white race of approximately the same age, was conspicuously smaller. The dimension measured transversely across from the middle of the cricothyroid membrane was 18 mm. as compared with 21 mm. in the white. The rima glottidis was 21 mm. as compared with 25 mm. in the white male and 25-30 mm. given by Nicolas.[6] There is a well-marked philtrum ventriculi (Merckel). The ventricle communicated with the larynx by a wide oval space, whose length was 15 mm. and breadth 6 mm. This was compared with a small larynx of a white man of about the same age, which was found to be 21 mm. by 8 mm.

*I can find no description of the larynx of a Chinaman in the literature; this appears to be the first one described. A full description will be published later.

The average given by Nicolas is 20 mm. As a result there is here a large respiratory space. The true vocal cords were separated from the false cords anteriorly by a well-marked horizontal depression, which extended across the middle line as a distinct narrow sulcus or canal of 1 mm. in depth. The floor of the sinus is horizontal, except that posteriorly it inclines downwards and lateralwards and is deepest posteriorly; here the ventricle passed behind the arytenoid cartilage, forming a considerable pocket 2 mm. deep posterior, lateral and inferior to the processus vocalis.

The appendix opens by an oval mouth 3.5 mm. long on right side, slightly larger on the left. This opening lies exactly in the middle line. A probe could be passed into the appendix for a distance of 10 mm. on both sides.

The characteristic features of the ventricle were:

(1) pouch behind arytenoid,

(2) anterior sinus,

both of which are Simian characters.

ORANG-UTAN.

The orang was a well developed female of 18-20 months, which died of bronchopneumonia.

The ventricle is connected with the larynx by a mere chink between the true and false vocal cords. From this opening the ventricular cavity extends downwards behind the true vocal cords for a distance of 8.5 mm., then curves upward on to the lateral wall, which is 4.5 mm. distant from the tip of the true vocal cord. The medial wall anteriorly undermines the false vocal cord to a height of 0.5 mm. Anteriorly the true and false vocal cords do not unite, but their edges come into close apposition. The ventricles of the larynx are here connected by a well-defined canal, 1.5 mm. in depth and almost circular. This canal is formed by the union of the true and of the false vocal cord of one side with corresponding cords of the opposite side. Owing to the close apposition of the edges of the true and false vocal cords, the canal comes most clearly into view when the larynx has been opened in the middle line posteriorly or when the thyroid has been divided in the middle line anteriorly. Posteriorly the true and false vocal cords meet and form an uninterrupted membrane extending over the posterior part of the ventricle. Below the membrane the ven-

tricles extend for a distance of 6.5 mm. behind and below the arytenoid.

The laryngeal appendix communicates with the ventricle by an oval mouth in the middle of the roof of the ventricle measuring 3.5 mm. in length. It consists of an intralaryngeal part and an extralaryngeal part often called the laryngeal sac. The intralaryngeal part of the sac is a short canal with collapsible walls.

The extralaryngeal sac communicates with the intralaryngeal sac by a slightly dilatable opening 6 mm. by 2.5 mm. (Fig. 6.) The long axis of this oval corresponds with and lies adjacent to the inner surface of the thyroid cartilage, the anterior end of this oval lies within 6 mm. of the middle line of the thyroid, and the whole opening of the extralaryngeal sac lies more anterior than posterior. A probe can be easily passed from the ventricle upwards and outwards into the extralaryngeal sac. It is then seen that the canal pierces the thyrohyoid membrane lateral to m. thyreohyoideus, and opens into a soft, loose-walled cavity, whose walls are thrown into numerous folds. The extralaryngeal sac was only covered by skin and platysma muscle. On account of the accidental removal of part of the sac on each side during the postmortem examination it was impossible to estimate its full dimensions; but it appeared to correspond in form and in size to the sac figured by E. Mayer.[7]

The most distinctive features of the ventricle and its appendages are:

(1) Their union across the middle line anteriorly.
(2) The pouch-like cavity posteriorly behind the arytenoid.
(3) The extralaryngeal sacs.

MACACUS RHESUS.

In a large Rhesus monkey, the anteroposterior diameter of whose larynx from the middle of the cricoid was 13 mm., the entrance to the ventricle is a mere slit. The length of the true vocal cord is 7 mm. Near the tip of the processus vocalis the true and false cords come together and form a membranous band 1.5 mm. in extent to the border of the arytenoid. This aids in forming the posterior recess of the ventricle which passes behind the arytenoid for a distance of 2.5 mm. The floor of the ventricle is almost level with the edge of the true

vocal cord, and the false vocal cord is only slightly, if at all, excavated, except where the appendix comes off. Anteriorly the true and false vocal cords approximate near the middle line. No canal or sulcus exists as in the orang; on the other hand, the cords of each side are separated by a vertical median furrow which passes up into the entrance of the median sac, so that a probe passed from below up the furrow passes into the sac.

The appendix passes 6 mm. beyond the tip of the false vocal cord.

The median or third sac comes immediately into view when the thyrohyoid muscles are lifted. It is a large flaccid walled sac, which fits into the excavated body of the hyoid above and lies below in the notch of the thyroid cartilage, to the upper border of which it is firmly fixed. It can be easily detached from the hyoid. It communicates with the larynx by a short canal opening, as above described, at the angle formed by the insertion of the epiglottis on the thyroid cartilage—an angle in this case of 120 degrees.

MARMOSET.

The aperture between the true and false vocal cords is a mere slit. The ventricle extends anteriorly to within 0.5 mm. of the middle line. No transverse sulcus connects them; on the other hand, as in the Rhesus, they are separated by a median longitudinal gutter. At the upper part of the median gutter lies a marked depression suggesting the opening of a median sac—but no trace of any sac can be seen on careful dissection. Above this depression the epiglottis springs forward at an angle of about 160 degrees. A probe passed up from the ventricle into the appendix reaches into a small cavity in the hyoid near the middle line. The body of the hyoid is expanded, being 1 cm. broad in the middle line, and indicates the position where both appendices meet together though they do not fuse.

In microscopic section the walls of the ventricle are seen to have many folds. The appendix is found to a great extent surrounded by cartilage; one might say that it lies in a cartilaginous cavity. Attached to the wall of this cartilaginous cavity are numerous bands of dense fibrous tissue, which disperse themselves in the elastic and connective tissue around the appendix; but no muscular tissue is seen.

II.—THE RELATION OF THE M. THYREOARYTAENOIDEUS TO THE VOCAL CORD.

There is one muscle which, from its anatomic position, seems admirably located for the production of various modifications of sound, and to which one looks for some explanation of the diverse qualities of sound, namely, the m. thyreoarytaenoideus. A comparative study shows that this muscle presents marked differences in its relation to the vibratory mechanism in the different families of the Anthropoidea. Also great individual variations are observable, not only among the races of man, but even in our own species. In each case the muscle was examined both in gross dissection and in coronal serial sections.

MARMOSET.

In this animal the true vocal cord projects as a triangular prismatic mass above the level of the ventricular floor, with base below and apex above. Its dense connective tissue contains elastic fibers and glands, but no muscles. The thyroarytenoid muscle lies some distance below the cord, and is seen as one complete mass, which passes uninterruptedly from its thyroid origin to its arytenoid insertion. It lies close to the fibrous tissue, but at a considerable distance from the ligamentum vocale; no fibers are seen breaking off to enter the fibrous tissue; no fibers pass from it around the ventricle or appendix. (Fig. 1.)

MACACUS.

The true vocal cord is a blunt projection with thickened fibroelastic tissue. The fibers of the thyroarytenoid are separated from it by loose connective tissue. This muscle extends as one mass across from thyroid to arytenoid, and rises only slightly above the floor of the ventricle; it does not show any separate muscle bands extending into the ligamentum vocale. No muscle tissue is seen in the false vocal cord. In the false vocal cord lies a mass of cartilage; imbedded in the loose connective tissue of the false vocal cord are several bundles of dense connective tissue, in which lie strands of elastic fibers. (Fig. 2.)

SIMIA SATYRUS.

In the orang the muscle tissue lies well beneath and does not enter into the triangular prismatic mass which forms the vocal

cords. The thyroarytenoid is to be regarded as a compact muscle passing uninterruptedly from thyroid cartilage to arytenoid. The fibrous tissue which surrounds the muscle is, however, in closer relation to the elastic membrane than in the macacus. In some of the microscopic sections there appear strands of muscle fibers which enter between the fibers of the ligamentum vocale. These appear as distinct and separate muscle bands and suggest the distinct muscle bands which form so characteristic an appearance in the true vocal cord of man. (Fig. 3.)

HOMINIDAE.

In the white races the main structure of the muscle is generally recognized. It takes origin from the middle line of the thyroid cartilage, from the cricothyroid membrane, receiving a few fibers from the upper margin of the cricoid cartilage, where its lower border is in contact with the m. cricoarytaenoideus lateralis. Its fibers sweep up and back and have an insertion into the anterolateral face of the arytenoid, its external border and muscular process, and into the point and inferior face of the processus vocalis. A number of the upper fibers reach the arytenoepiglottic fold and the epiglottis, constituting the m. thyreoepiglotticus.

For descriptive purposes the muscle is divided into two great but purely artificial divisions, namely, (1) m. thyreoarytaenoideus externus—the broad lateral band which sweeps above the level of the true vocal cord and lies in relation to the sinus and appendix, and of which the m. thyreoepiglotticus forms a part; (2) m. thyreoarytaenoideus internus, or m. vocalis, a triangular prismatic mass whose medial surface lies adjacent to the ligamentum vocale and the conus elasticus, and which constitutes a considerable part of the vocal cord.

There is no laryngeal muscle about which there has been so much dispute as the m. vocalis, especially in regard to its relation to the ligamentum vocale. A direct insertion into the ligamentum vocale is accepted among others by Ludwig, Kolliker and Henle; and denied by Luschka, Meyer and Kanthack. At present the question is still an open one. But all are agreed in regard to the intimate relation of the m. vocalis to the cord.

An excellent review of the literature well up to date is given by Lewis.[8] He describes the fibers of the m. vocalis as pass-

ing in between the elastic fibers of the ligament and surrounded by them; but he never finds transition of muscle fibers into elastic fibers. The muscle fibers thus closely related to the elastic tissue of the ligamentum vocale may, he considers, by contracting, make tense the vocal ligament. Moreover, fibers of the ligamentum vocale are reinforced by additional fibers from the perimysium of the m. vocalis, and in this way the cord may be rendered tense. He suggests that these reinforcing fibers may act as follows: Where the arytenoid is adducted, these fibers will abduct the cord and render it tense.

CHINAMAN.

The muscle thyroarytenoid projects into the true vocal cord and forms a well-marked m. vocalis, which, however, cannot be separated from the m. thyreoarytaenoideus (externus). The superior and medial fibers of the m. vocalis, especially near the arytenoid end, insinuate themselves well within the fibrous and elastic tissue of the true vocal cord. Some of these bands are relatively small, consisting of six to ten muscle fibers; others contain three or four times that number. The fate of these individual bands is hard to determine; they ultimately diminish in number and in size, and disappear in the tissue of the cord.

It was found impossible to compare accurately the relative size and relation to the ligamentum vocale of the m. vocalis in the white man and Chinaman. The different conditions under which the tissue had been fixed and preserved had altered the parts considerably. Still, it appeared that in this Chinese larynx the m. vocalis was farther away from the apex of the true vocal cord, and that the muscle near the apex was more split into sections by the fibrous tissue. (Fig. 5.)

FUNCTIONS OF THE LARYNGEAL SACS.

Very varied are the opinions held in regard to the function of the appendices of the larynx, and we will not go far astray if we say that at present their physiologic action is unknown. It is interesting to note the different opinions that have been put forward:

(1) It has been very generally held that they act as resonators. This seems to hold in regard to the median sac of Mycetes, the howling monkeys, and to the varieties of Ma-

cacus which I have examined. In these animals the nature of the sac and its relation to the cavity in the hyoid seem adapted to act as a resonator. In addition the mouth of the sac, lying in the middle line at the obtuse epiglottic laryngeal angle, gives further emphasis to this view. It is generally believed that the peculiar piercing cry of the howling monkey is due to this. But in the higher apes with soft sacs, with walls often extending to the clavicle and normally in apposition, it is not possible for them to act as resonators under ordinary conditions.

(2) Fraenkel[9] has suggested that in man one purpose is to pour secretion on the vocal cords, and so to keep them moist. However applicable this function may be in the white man with a horizontal floor, I can see very serious objections to the general application of such an hypothesis. I doubt its adequacy in the Chinaman I have just described, in the negro larynx as described by Gibbs, or in the apes. In these the floor often sinks below the level of the true vocal cord, and it appears to me the secretion would collect in the sulcus lateral to the cord. Moreover, in the apes the glands approximate so closely to the apex of the cord as to render such a secretion unnecessary.

(3) Vrolick[10] has suggested that the extralaryngeal sacs in the apes lighten the upper part of the body in climbing. An allied suggestion is that as the head of the ape is relatively heavy, we have it placed, as it were, on an air cushion, which takes a good deal of weight off the trunk and allows the animal to assume an erect position. Even were these suggestions suitable, their limitations to a few species would be detrimental to their general applicability.

(4) Deniker[11] believes that the extralaryngeal sacs act as a protection for the vessels of the neck in the apes. He points out that the heavy face bones increase the pressure forward and so are apt to produce constriction of the cervical vessels.

Interesting as these suggestions may be, their applicability to only a few species seems to call for a general principle on which to base an hypothesis capable of explaining the presence of these widely distributed diverticula. It has always appeared to me that if any general principle underlies their presence and variable development, one must seek for such along the line of the general development of the larynx. Now, con-

fining my attention chiefly to the anthropoidea as I have done in this paper, I believe that the general development of the larynx has been progressive along the lines and to satisfy the demands of interrelational life. If this be so, we ought to look in this principle for some explanation of the significance of these sacs.

Every one recognizes that the cry of the animal is greatly modified by its emotional states. I would suggest that in emotional stress these inert sacs can be called into play, can be distended and modified in form; so there can be given to the vocal emission a tone of peculiar and significant intensity. In making this suggestion I do not forget the important role which may be played under such condition by the mouth, nose and nasopharynx. But I do believe that we have here, in the immediate neighborhood of the cords, structures which may undergo modifications most suitable for this purpose. I would suggest that in the laryngeal sacs we have analogous structures for analogous purposes to the esophageal sacs of birds such as the pigeon, which inflates the throat and crop when cooing to a mate or neighbor. To elaborate this suggestion would take one far beyond the limits of this paper. I, therefore, confine myself to two examples in the anthropoid apes, which will exemplify my contention. The monkeys I have chosen are one from a New World family, Cebidea, and one from an Old World family, Simiidae. These two families are not only "absolutely distinct at the present day, but they have been, so far as we know, for a very long time, since no fossil remains of monkeys at all intermediate have been so far discovered." (Beddard.[12])

(1) It appears to me that there is sufficient evidence to show that the characteristic cry of the Mycetes, the howling monkey (family Cebidae), is not intended to frighten his enemies, as is generally stated, but is used to modify the voice in order to express mental states and emotions.

Professor Tower of the Chicago University Biological Department, has kindly furnished me with some notes in regard to the howling monkey, the results of his observations of them in the forests of Central America. Since so few statements by competent observers are in the literature, and since Professor Tower's observations are not only of great interest, but so opposed to the usual statements in our text-books, I have

dwelt on this more fully than is requisite for my particular purpose.

In the forest the monkey begins to howl about four in the morning, sometimes earlier, depending on whether the night is very warm or very cold, or if there is a bright moon. Usually it is an old male who starts when the forest is very still. He is answered from different directions by a second, a third or a fourth; very rarely two are howling at the same spot. So they cry backward and forward till about seven in the morning, when the feeding activities of the day begin. The cry is not heard as a rule very long after sunrise. In the cool of the evening the howling is resumed. The cry is gutteral, not a shriek; it is like that of a man being throttled. It is not always the same note; the sounds emitted vary in range, in pitch and in individuality. This individuality is very marked. A monkey may utter six or seven sounds of different pitch, the whole lasting about thirty seconds and then being repeated. The others answer, each one varying these sounds.

The howling is most marked during the breeding seasons. The chief breeding season is in June, the young are born in December. The next or minor breeding season is in January. But breeding is not confined altogether to these two seasons, but is more generally diffused than in the lower mammals and approximates to man.

The attitude of the monkey when he howls is very characteristic; he raises himself up, fixes his arm on the limb of a tree, raises his head and howls. In other words, he appears to be fixing his extrathoracic muscles. A gunshot will at any time stop the howl. It is very doubtful if the cry is heard at more than half a mile. Experience in hunting shows that one can usually locate the howler within a quarter of a mile. Of course, a good deal will depend on the wind. Again, when one has been hunting in the forest the ear gets attuned to the forest so that any disturbance, even at a great distance, is felt rather than heard. So although one may not recognize the sound as a howl, still one may recognize a disturbing element in the air and education and experience does the rest.

(2) Our present evidence seems to point to the conclusion that the extralaryngeal sacs of the Simia satyrus, orang-utan (family Simiidae) are but rarely distended, and then only under emotional stress. The sacs are never distended during

forced expiration. There are few direct and careful observations which have been published in regard to the distension of these sacs, but these support the statement that in captivity the extralarygeal diverticula are seldom distended, and then only in emotional states. The following interesting observations are given by Meyer[13] in regard to the orang Rolff in the zoological gardens in Berlin: "Unser Rolff blâhte sich auf wenn er sich argerte und denjenigen schrecken wolte, welcher ihm Missvergnügen bereitete." In strong expiratory actions such as blowing up a fire, the extralaryngeal sacs were never distended.

THE LARYNGOCELE AND EXTRALARYNGEAL SAC.

Connected with the varying size of the appendix is the question of the origin of the laryngocele and the lateral extralaryngeal sacs in man. Are they pathologic or are they a phylogenetic reversion? As is well known, the laryngocele is an enlargement of the appendix which projects beyond the normal limits of this diverticulum, for example into the sinus pyriformis or above the hyoid into the glossoepiglottic fossa. The extralaryngeal sac is an enlargement of the appendix which projects through the thyrohyoid membrane lateral to the thyrohyoid muscle and lies under the platysma muscle. Of these the two classical examples in man are the double sac described by Gruber[4] (Fig. 7) and the single sac described by Sclavunos.[5] (Fig. 8.)

There appears to be sufficient evidence to suggest that certain enlargements of the appendix are pathologic, *e. g.*, the presence of a tumor blocking the aditus laryngis causing the dilatation of the ventricle. Included in this class must be the cases quoted by Larrey of the prevalence of laryngocele among those blind Mohammedans who are employed to chant verses of the Koran every hour of the day and night. But can one with Hanseman[14] dismiss the subject with the general statement that all are Missbildungen, to be classed with hernia, due to a congenital or acquired weakening of thyrohyoid membrane and as a consequence dilatation subsequent to respiration. I would here remind you that *post hoc* is not necessarily *propter hoc,* and, further, that such dilatations are not always accompanied by pathologic legions or with a history comparable to that given by Larrey. I would ask you to consider that the

close analogy these sacs have to those found in the primates, for example in the orang, suggests that they may be phylogenetic reversions. In this connection let me remind you that in the orang and gorilla the extralaryngeal sacs are not present at birth; they are appendages which begin to appear in the early months of extrauterine life.

In addition ontogeny throws some light on this question. It has been brought out by a study of the fetal larynx, especially by Sclavunos[15] and Bartel,[16] that appendices are there always present, are always well developed and arise from the whole ventricular roof. In a large proportion they pass far above the upper border of the thyroid, even to the root of the tongue. In one case quoted by Sclavunos the dilatation occupied not only the glossoepiglottic fossa, but the greater part of the sinus pyriformis. Normally a diminution occurs in extrauterine life. There would, therefore, appear to be some justification for regarding them as a persistence of the fetal conditions, and this would at once strengthen the hypothesis that some, at any rate, must be regarded as phylogenetic reversions. It is interesting here to note that the first case quoted of a "laryngocele" was in a deaf mute of forty years of age, which Rudinger, who described it, believed to be a case of phylogenetic reversion. As Bartels says, it is difficult to understand how the inarticulate cry of a deaf mute could produce a laryngocele.

M. THYREOARYTAENOIDEUS.

In a comparative study of the musculature directly related to the cord, the outstanding facts appear to me to be a gradually increasing complexity of the m. thyreoarytaenoideus and a closer approximation of it to the ligamentum vocale. The internal part of the muscle gradually enters into closer relation to the cord, finally becomes incorporated with it, and in man sends distinctly separated bundles into its fibroelastic tissue which constitute the m. vocalis. In the marmoset and macacus the m. thyreoarytaenoideus is one compact muscle bundle lying apart from the vocal cord and not incorporated in it. In the orang this muscle approaches closer to the cord and a few muscle bands are separated off and partly embedded in it. This is in complete agreement with Giacomini,[17] who has shown that in the gibbon and chimpanzee this incorporation has advanced even farther and there begins

more distinctly to be seen that characteristic appearance so distinctive of the musculus vocalis of man. When one studies the walls of the ventricle, there is noted in the marmoset no muscle tissue around the ventricle. In the orang muscle fibers pass around the interlaryngeal portion of the ventricle. In man they are distinctly seen, but apparently varying in amount in different individuals, and it may be in different races, for in my Chinese larynx they are less abundant than in the white man of the corresponding age.

These facts suggest a function directly related to the true vocal cord and to its physiologic activity. They show the development of a mechanism by which a finer or more exact control of the vocal apparatus can be obtained. This incorporation of the muscle in the cord will bring the activities of the cord directly under the control of the nervous system. If it be that the sacs can be used to vary the voice in states of emotion, how much more exact, how much more capable of development will such a muscular mechanism be?

From a comparative study of the larynx one fact appears to me clearly to stand out, namely, that we have here an organ whose recent phylogenetic history shows marked developmental progress and whose present state is that of great variability. The latter fact would itself suggest developmental activity. In this activity I feel that we do not realize as fully as we ought the important part which has been played and is still being played by the psychic state. We constantly recognize the important relation of sex to the vocal organs; but is not this but one aspect of the role played by the emotions? Is it not the case that mere words can never convey to us that finer expression of the emotions with which the voice can thrill us? And if this be so, must not this inevitably tend to further development of the larynx? In taste and in smell, and it may be in the eyes, we have a marked restriction of the peripheral distribution of the respective fields; but in voice, with its natural ally, speech, we have an expansion of the territory which is being utilized. Here the progress is markedly forward and it may be that we shall yet be able to demonstrate subtile anatomic differences comparable to the higher physiologic functions which it manifests in man.

In the preparing and examining of specimens necessary for this paper, I have been ably assisted by one of my students, Miss Jeanette Obenchain.

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EXPLANATION OF FIGURES 1, 2, 3, 4 AND 5.

Figures 1 to 5 were drawn from microscopic sections, and figure 6 from a prepared specimen, by Miss Hill of the Department of Anatomy, University of Chicago. Figures 7 and 8 are photographs of plates from the works quoted.

These figures are from sections at middle third of true vocal cord near arytenoid end, showing the relation of m. thyreoarytenoideus to vocal cord. (Zeiss comp. occ. 4, obj. A2 outlined with camera lucida.)

p. v............plica vocalis (true vocal cord).
p. ventr........plica ventricularis (false vocal cord).
v. l............ventriculus laryngis (Morgagnii).
a. v. l...........appendix ventriculi laryngis.
m. ta...........m. thyreoarytenoideus.
m. v............m. vocalis.
g...............glands.
c...............cartilage.

Figure 1.—Marmoset (family Hapalidae).

Figure 2.—Macacus Rhesus (family Cercopithecidae). b—thickened fibroelastic tissue external to muscle with loose tissue superior to it.

Figure 3.—Young orang-utan, Simia satyrus (family Simiidae). f—muscle fibers separating off from m. thyreoarytenoideus and entering tissue of true vocal cord.

Figure 4.—Hominidae—white man.

Figure 5.—Hominidae—Chinaman. Section of true and false vocal cord with ventricle. (Zeiss comp. occ. 2, obj. A2, outlined with camera lucida.)

Figure 6.—Communication between extra- and intralaryngeal sacs of young Simia satyrus, orang-utang. Whole of left extralaryngeal sac cut away: part of right sac attached to deeper structures is seen extending slightly to left of middle line.

C and C'—openings in thyrohyoid membrane between extra- and intralaryngeal sacs of right and left side.
S—part of right sac attached on its deeper surface.
M—thyrohyoid membrane.
H—body of hyoid bone.
I. H. M.—infrahyoid muscles.
S. H. M.—suprahyoid muscles.
T. R.—first tracheal ring.

Figure 7.—Lateral extralaryngeal sacs in man reproduced from "Ueber einen Kehlkopf des Menschen mit theilweise ausserhalb desselben gelagerten seitlichen Ventrikelsacken," by Dr. Wentzel Gruber (Archiv f. Anat. Physiol. u. wissensch. Medicin., 1874, p. 604, Taf. XV, Fig. 2).

Y and Y'—right and left extra-laryngeal sacs.
A—cartilago thyreoidea.
B—cartilago cricoidea.
2—corpus ossis hyoidei.
6—glandula thyreoidea.
a—ligamentum hyo-thyreoideum medium.
f—m. sternohyoideus (turned upwards).
g—m. omo hyoideus (turned upwards).
h—m. hyothyreoidus.
k—m. cricothyreoideus.
s.—n. laryngeus superior.
t—art. laryngea superior.

Figure 8—Extra-laryngeal sac in man from Sclavunos—reproduced from W. L. H. Duckworth's Morphology and Anthropology. University Press, Cambridge, England, 1904.

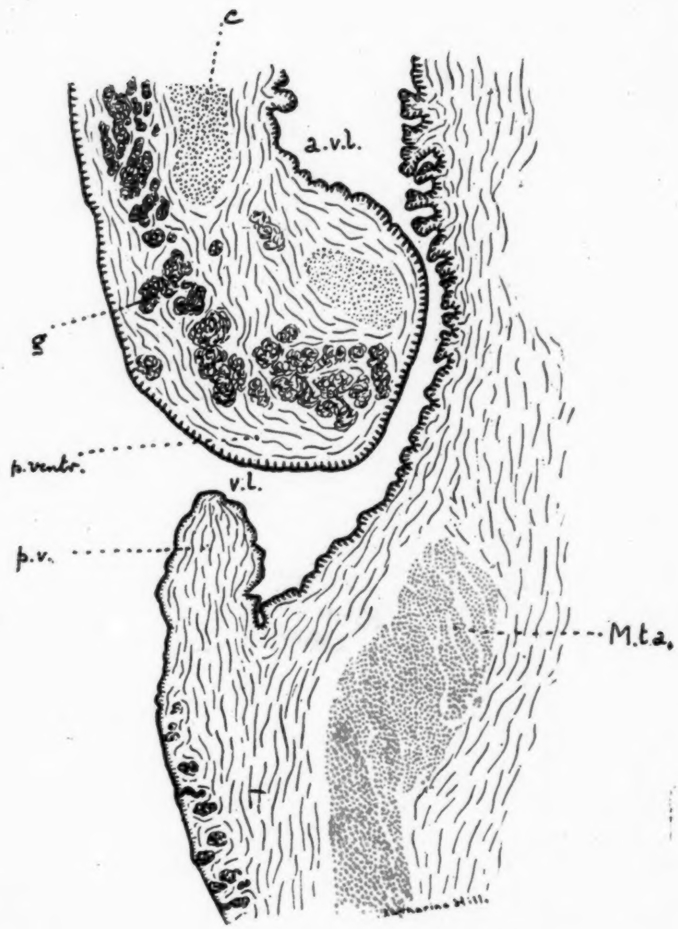

FIGURE 1.

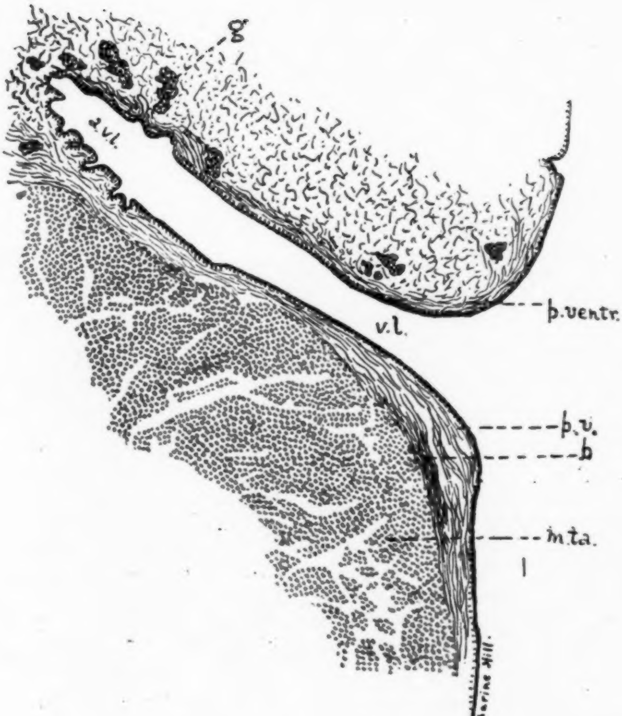

FIGURE 2.

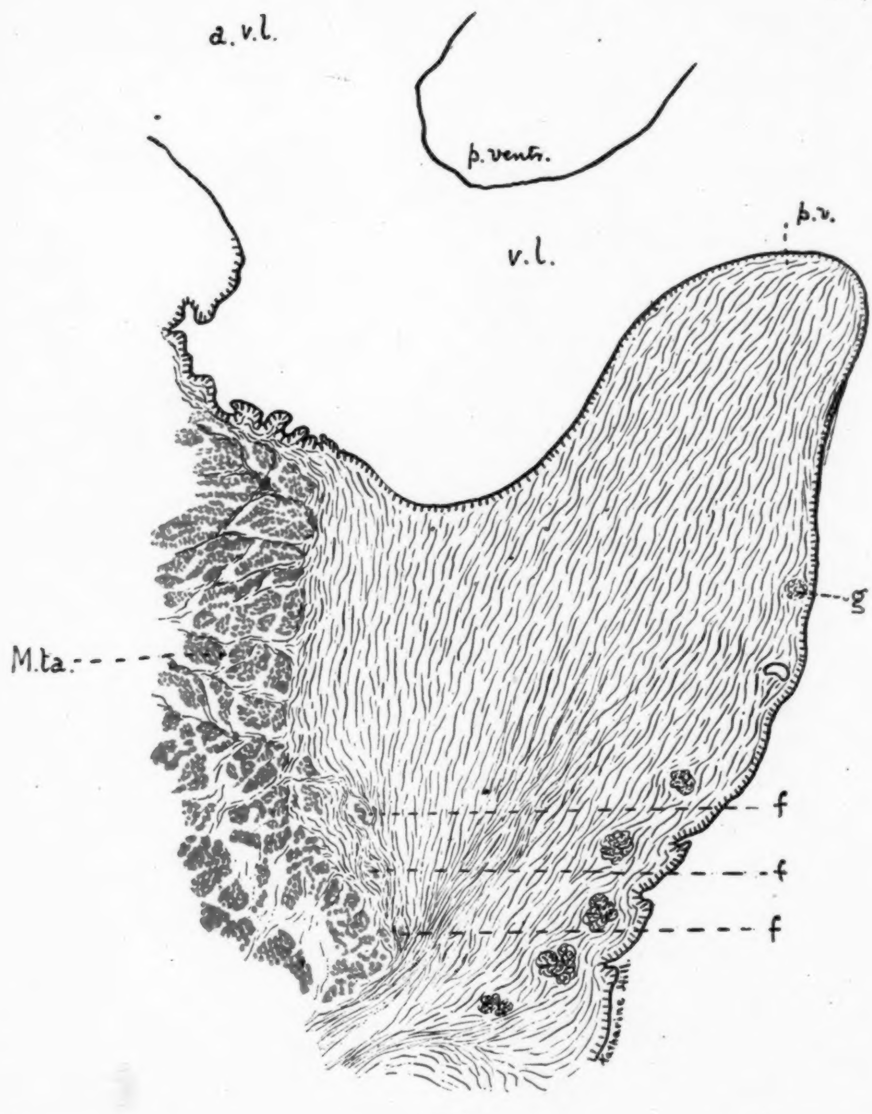

FIGURE 3.

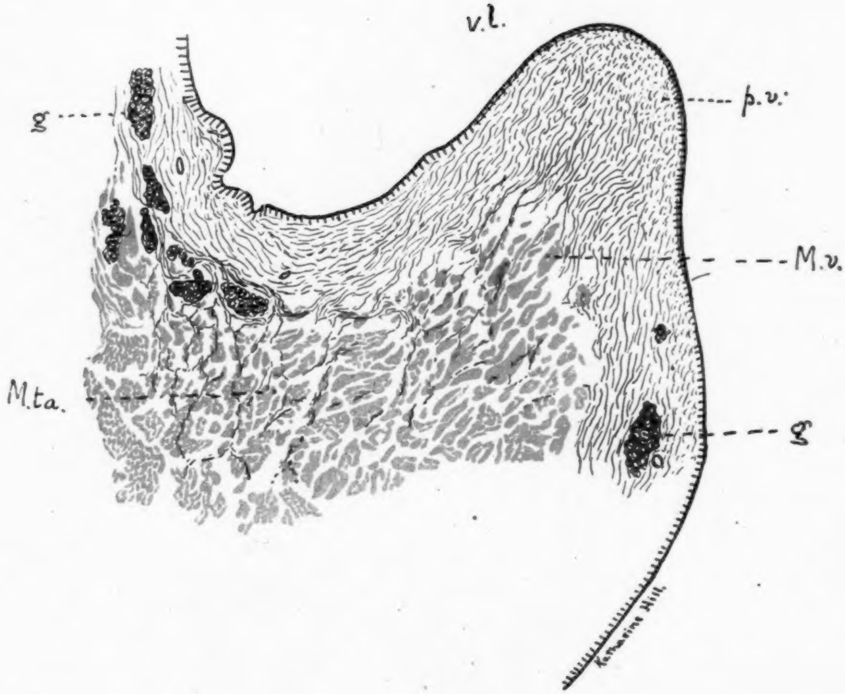

FIGURE 4.

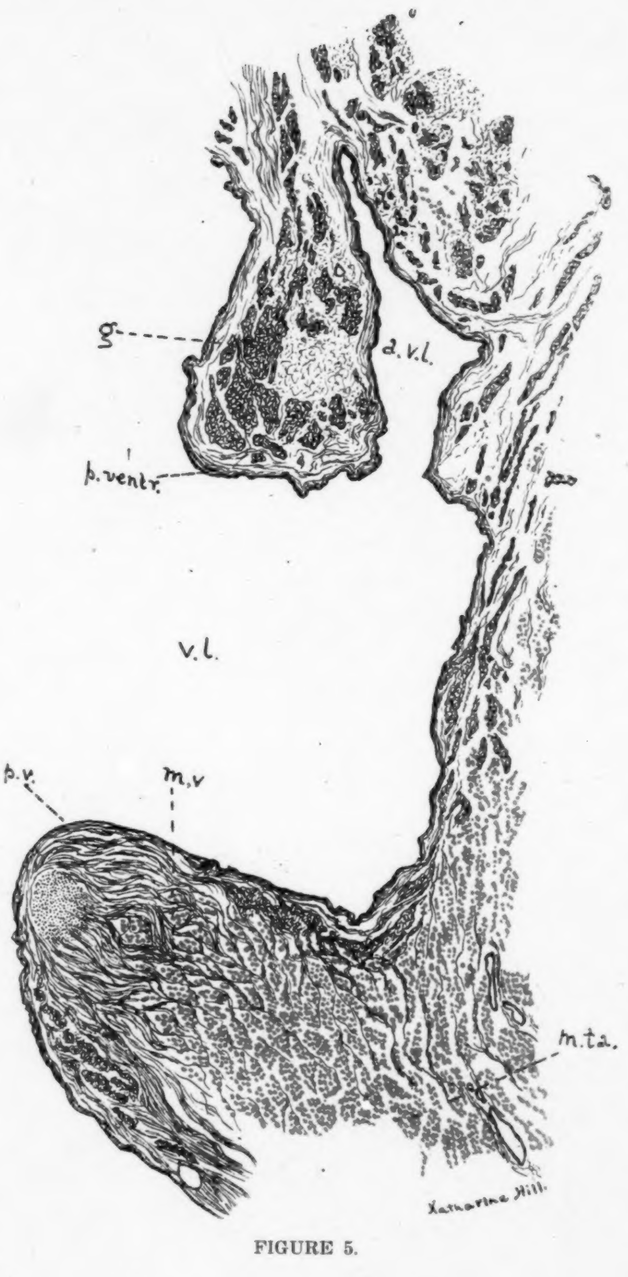

FIGURE 5.

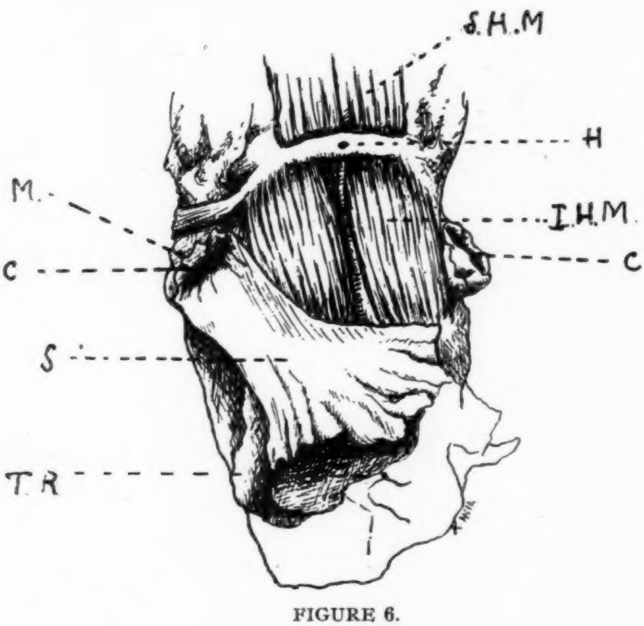

FIGURE 6.

FIGURE 7

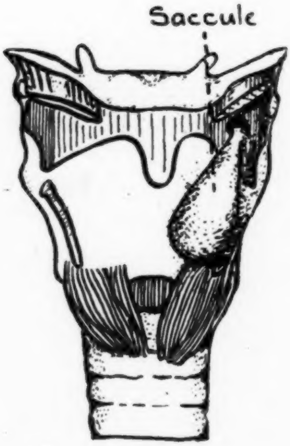

FIGURE 8

LVIII.

THE PHYSIOLOGY OF TONE PERCEPTION.

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PART I.

A discussion of the modern theories of sound perception begins naturally with a consideration of the work of Helmholtz. The theories of sound perception that had found expression for several centuries preceding the time of Helmholtz embodied, however, the fundamental conceptions of the Helmholtz theory, to-wit: that tone perception is dependent on the vibration of structures in the cochlea in response to the impulses of sound waves, and, second, that this response takes place in different parts of the cochlea for the tones of varying pitch. It was the work of Helmholtz to elaborate these ideas and to give them their greatest scientific support.

My own interest in the question was aroused by the finding of certain anatomic conditions which convinced me that the basilar membrane theory of Helmholz is untenable. My studies in the anatomy of the labyrinth convinced me also that from anatomic data alone we are able to determine at least the probable role of the several structures in the cochlea which take part in the perception of sound, and that we are in this way able to establish a fundamental anatomic basis for the further study of the problem.

The reaction in the cochlea which results in the transference of sound waves to nerve impulses is apparently a physical one. For this reason the questions involved in the problem of sound perception are peculiarly dependent for their solution upon an accurate knowledge of the structures in the labyrinth. An investigation of the anatomy of these structures should form, therefore, the basis for the study of this problem. This seems all the more important since the subject is one that can be approached only indirectly and does not permit of actual demonstration. Most of the work on the problem of sound perception has been approached, however, from the stand-

point of the physiologist and of the psychologist. Relatively little use has been made of the assistance offered by anatomic study in the efforts to solve the problem. Theories have been worked out independent largely of anatomic considerations, and then an effort made to fit them to anatomic conditions. In this way fundamental errors have arisen which could scarcely have occurred had the problem been approached from the standpoint of the anatomist.*

A conspicuous feature in the anatomy of the inner ear is the close structural analogies found to exist between the three types of end organs in the membranous labyrinth; the macula acustica of the utricle and saccule, the crista acustica of the ampullae, and the organ of Corti of the cochlea. These end organs, in addition to a common origin in the primitive otic vesicle, have fundamentally the same histologic structure. Each end organ consists of hair-bearing cells and of a peculiar superimposed structure of epithelial origin. This latter structure in the cochlea is the membrana tectoria. In the macula acustica it is the otolith membrane, and in the crista acustica it is the so-called cupula.

This close structural analogy between these three types of end organs suggests that functionally we may expect to find them reacting to stimuli in much the same manner. The following conclusions regarding the response of the end organs to stimuli seem justified:

1. That the stimulation of all three end organs is a physical one.
2. That the actual structure wherein the transference of a physical to a nervous impulse takes place is the hair cell.
3. That the stimulation of the hair cells in each end organ is brought about by an irritation applied to their projecting hairs.
4. That the irritation of the hairs of the hair cells consists

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*Helmholtz, for example, first became convinced that the phenomena of subjective tone analysis could be best accounted for on the principle of physical resonance. He then sought to find the structure in the cochlea which could act as resonator and at the same time bring about a stimulation of the hair cells of Corti's organ. The rods of Corti seemed to resemble most a known type of resonator, and Helmholtz believed that in vibrating these rods in some way brought about a stimulation of neighboring groups of hair cells. This theory he discarded later and selected the radiating fibers of the membrana basilaris as the resonators. I believe we are able now to show that this conclusion of Helmholtz was also a mistake.

of an interaction between the hairs and their superimposed membrane, the membrana tectoria, the otolith membrane, and the cupula, respectively.

5. That the interaction between the hairs of the hair cells and this superimposed membrane is brought about in each instance by movements in this membrane.

It is generally conceded that these fundamental principles in the physiology of the end organs of the labyrinth are true for both the macula and the crista acustica. There does not appear to be any reason for believing that they do not hold equally true for the end organ found in the cochlea, the organ of Corti. The theory of tone perception should rest, therefore, on this fundamental proposition, that the stimulation of the hair cells of the organ of Corti consists of an interaction between their projecting hairs and the membrana tectoria, which interaction is brought about by movements in this membrane imparted to it by the impulse of sound waves passing through the endolymph.

This conception of the physiology of the cochlea, placing the active role for the stimulation of the hair cells in the membrana tectoria, is at variance with the generally accepted theory which attributes this function to the membrana basilaris. The origin of the idea that the membrana basilaris takes the active part in bringing about a stimulation of the hair cells of Corti's organ dates practically from the work of Helmholtz. This investigator in studying the phenomena of tone perception was convinced of the idea that subjective tone analysis finds its most plausible explanation in the principle of physical resonance. Helmholtz then inquired of anatomists for a structure in the cochlea which might seem suited to fill the role of a physical resonator. His first conclusion was that the rods of Corti filled this role by acting as a series of rod resonators. When it was shown that in certain animals capable of tone perception these rods were lacking, Helmholtz gave up this conclusion and later fixed upon the radiating fibres of the membrana basilaris as the structures which by responding in the several parts of the cochlea to tones of different pitch brought about a stimulation of different groups of nerve fibres for each tone in the scale.

It is interesting to note how this conclusion of Helmholtz attributing the active role in the stimulation of the hair cells

of the organ of Corti to the membrana basilaris has been accepted by those who have since worked with this problem, even by those who have attempted to substitute for the principle of physical resonance some other mode of action. Ewald,[1] for example, starts with the hypothesis that the stimulation of the hair cells of Corti's organ is dependent on the vibration of the membrana basilaris. He then constructs a model having a stretched rubber membrane representing the membrana basilaris, and by studying the vibration of this rubber membrane when sound waves are conducted into his model, he attempts to determine the manner in which the membrana basilaris itself responds to the impulse of sound waves in the labyrinth. Max Meyer,[2] also, does not accept the principle of physical resonance, but adopts the idea that the membrana basilaris fills the active role and builds up his theory on this hypothesis.

I believe we are justified in asserting that when we attribute the active role in the stimulation of the hair cells in Corti's organ to a structure other than the membrana tectoria, we are beginning our study of tone perception with a fundamental error in the physiology of the cochlea, an error which has found its way, however, into most of the work that has been done on this problem.

A careful scrutiny of the structures in the cochlea disclose, moreover, a number of anatomic conditions which clearly make it impossible for the membrana basilaris to fill the active role attributed to it by Helmholtz and his followers. The radiating fibres of the membrana basilaris apparently do not consist of independent bands, but the fibres are interwoven more in the nature of a flat tendon (Hardesty). These fibres also, though part of the cochlea, are so imbedded between cellular layers above and below that it is not easy to see how they can be acted upon by impulses in the labyrinthine fluids. According to the principle of string resonators we should expect, moreover, to find that as the fibres of the membrana basilaris become shorter toward the lower end of the basal coil, they would also become thinner and more tense. I have found, however, that just the opposite is the case.[3] The membrana basilaris toward the lower end of the cochlea invariably becomes thicker and frequently loses all resemblance to a vibrating structure at a point where a perfectly formed organ of Corti is still founl. However serious these objections may

seem, there is another anatomic objection which I believe constitutes an unanswerable argument against any theory which attributes the active role in the stimulation of the hair cells of Corti's organ to the vibration of the membrana basilaris. This is the presence of the blood vessel attached throughout the coils of the cochlea to the under surface of this membrane. This blood vessel, I have been able to demonstrate by injection experiments, is capable of the dilatation and contraction which other blood vessels in the body undergo when subjected to varying degrees of blood pressure, etc. It is essential for the Helmholtz theory or for any theory that attributes the active role to the membrana basilaris that this structure responds at all times equally to the same impulse. The presence of this blood vessel, subject to varying degrees of distention and contraction, makes such a response a physical impossibility, and renders these theories untenable.

On the other hand, the membrana tectoria seems not only to be the logical structure for taking the active part in the stimulation of the hair cells of Corti's organ, but it appears to be admirably suited anatomically to fill this role. Its delicate structure should render it suitable for responding to the slightest impulse passing through the endolymph, and its physical character is such that it must respond unvaryingly at all times to the same impulse.

Before discussing the manner in which the membrana tectoria probably responds to impulses of sound waves passing through the endolymph, let us consider for a moment the suggestion made by some that the stimulation of the hair cells of Corti's organ may be accomplished by the hairs receiving stimuli directly from impulses in the endolymph without the intervention of the membrana tectoria. Objections to this hypothesis are, first, such a theory would leave the membrana tectoria without a plausible function; second, such a mode of response for the hair cells in the organ of Corti would make this end organ functionate in a manner quite different from its analogous structures in the vestibule and semicircular canals, where the stimulation of the hair cells is unquestionably dependent on an interaction between their projecting hairs and the superimposed structures, the otolith membrane and the cupula; third, the relation between the hairs of the hair cells of Corti's organ and the under surface of the membrana tec-

toria is such as to make it impossible for these hairs to receive impulses direct from the endolymph, but that these impulses must first pass through the membrana tectoria. This is the sort of relation we should expect to find between the hair cells of Corti's organ and the membrana tectoria, since it is the relation known to exist between the hair cells of the macula acustica, and the crista acustica, and the otolith membrane and cupula, respectively. In my work on the labyrinth of the pig I have been able to demonstrate that in both the newborn and the adult pig this is the normal relation between these hair cells and the membrana tectoria; the hairs are normally in actual contact with this membrane. Kolmar also demonstrated this relation in the labyrinth of the adult pig.[4]

PART II.

We may begin then with the fundamental proposition that the stimulation of the hair cells of Corti's organ must be brought about by movements in the membrana tectoria imparted to it by the impulse of sound waves passing through the endolymph. The problem then resolves itself into determining what mode of response in the membrana tectoria will best explain the phenomena, normal and pathologic, associated with sound perception.

The following facts in the anatomy of the membrana tectoria are of importance here: This membrane has a delicate semigelatinous structure, suitable for responding to impulses passing through the endolymph. It is not a homogeneous structure, but is made of an immense number of delicate fibrilli imbedded in a gelatinous matrix. There is decided variation of size in this membrane from one end of the cochlea to the other, being much smaller toward the lower end of the basal coil and becoming gradually larger toward the apex of the cochlea. The membrane does not lie free above the organ of Corti, but is in actual contact with the hairs of the hair cells.

In attempting to determine the probable mode of response of the membrana tectoria to the impulse of sound waves one should keep clearly in mind certain physiologic and pathologic phenomena to be accounted for. The most important of the physiologic phenomena is the faculty which the ear possesses of subjective tone analysis. The complex impulses

which impinge on the organ of hearing when several tones are sounded simultaneously is analyzed subjectively so that we are able to distinguish each of the tones entering into the complex. There are two theories as to where this subjective tone analysis is accomplished. According to one it is accomplished in the peripheral apparatus in the cochlea; according to the other theory, this analysis is a function of the cerebral cortex. The first hypothesis, that of peripheral tone analysis, makes different groups of fibers in the cochlear nerve respond to different tones in the scale. The second hypothesis, that of central tone analysis, assumes that the cochlear nerve trunk responds as a whole to every tone in conveying impulses to the cerebral center. This latter hypothesis is known as the telephone theory of Rutherford and is clearly untenable from the standpoint of the physiologist, as has been shown especially by Ewald[5] and McKendrick[6]. The so-called secondary phenomena of tone perception, such as the phenomena of beats, different tones, etc., receive their only plausible explanation on the hypothesis of a peripheral rather than a central analysis.

Of the pathologic phenomena to be considered in a discussion of this problem, the most important is the occurrence of so-called "tone islands" and of defects in the midst of the tone scale. These phenomena are known to occur only in connection with disease of the labyrinth. It is not uncommon to find in cases of deafness of labyrinthine origin the preservation of circumscribed areas of hearing in the midst of the scale, as well as the occurrence of circumscribed defects in the scale. This well known pathologic phenomena occurring apparently only in connection with disease of the labyrinth, seems to be accounted for plausibly only on the hypothesis that circumscribed areas in the cochlea have to do with the perception of particular tones, that is, on the existence of peripheral tone analysis. Another pathologic phenomenon to be considered in connection with this problem is the production of a circumscribed defect in the tone scale resulting from an injury produced by a shrill whistle of the same pitch. This phenomenon also points to a localization of the perception of the various tones in separate parts of the cochlea, that is, to a peripheral tone analysis. There is still another pathologic phenomenon which has an important bearing on this

problem, that is, the production of circumscribed areas of degeneration in the organ of Corti as the result of overstimulation by tones of a certain pitch. The demonstration of this fact was first made by Wittmach.[7] The work has since been carried on by Yoshii[8] under the direction of Prof. Siebenmann. It is perhaps the nearest approach to an actual demonstration of the theory that the perception of the various tones takes place in separate and distinct parts of the cochlea, a demonstration, in other words, of the theory of peripheral tone analysis. The pathologic phenomenon of "diplacousis" where a patient hears a tone in the affected ear of a pitch different from that heard in the normal ear, seems also to be accounted for plausibly only on the hypothesis of the existence in the cochlea of a structure which vibrates differently in its several parts for different tones; that is, on the existence of peripheral analysis.

Returning now to the problem of determining the probable action of the membrana tectoria when acted upon by the impulse of sound waves in the endolymph, three possible modes of response suggest themselves. By the first the minute impulses caused by the tones highest in the scale would throw into vibration only that part of the membrana tectoria nearest the beginning of the basal coil where this membrane is very small. Each tone lower in the scale would then cause vibrations in a larger and larger extent of this membrane until the lowest tones we perceive would throw this entire structure into vibration. Such a response in the membrana tectoria, it would seem, might account for the phenomena of subjective tone analysis, since for each tone in the scale a different group complex of hair cells is stimulated. A fundamental objection, however, to this hypothesis is that it seems to offer no plausible explanation for such phenomena as "tone islands" or of defects in the midst of the tone scale, nor does it explain how circumscribed degenerations in the organ of Corti in different parts of the cochlea are produced as the result of overstimulation from tones of a certain pitch.

The second possible mode of response in the membrana tectoria to sound waves that suggests itself is that it is thrown into vibration throughout its entire extent by every tone in the scale, the highest as well as the lowest. Physically this might seem to be quite possible. Such a response in the mem-

brana tectoria would result, it seems, in a stimulation of the hair cells of the cochlea in one of two ways; either the vibration in the membrana tectoria throughout its entire extent for every tone would stimulate every hair cell in the cochlea for each tone in the scale, or the hair cells of the cochlea might be stimulated in different groups for each tone, just as they would be in the Ewald theory, by the vibration of the membrana basilaris. According to this last method, the undulations of the membrana tectoria would cause a stimulation only of those hair cells opposite the crests of the waves. In this way different groups of hair cells might be stimulated for each tone in the scale. The first hypothesis, that all the hair cells in the cochlea are stimulated for each tone in the scale, is but a restatement of the principle of the telephone theory of Rutherford, an untenable hypothesis.[9] Fundamental objections to the second hypothesis that different groups of hair cells scattered throughout the cochlea are stimulated for each tone in the scale as in the Ewald theory are:—

1. Such a theory fails to account for the existence of "tone islands" or defects in the tone scale, nor does it explain the occurrence of circumscribed degenerations in the organ of Corti as a result of overstimulation by certain tones.

2. There appears to be a fundamental anatomic objection to such an hypothesis since the normal relation between the hairs of the hair cells and the membrana tectoria, one of actual contact, would appear to make it impossible for vibrations in the entire extent of this membrane to fail to stimulate all the hair cells throughout the cochlea. Such an action, as pointed out above, brings us again to the basis of the untenable telephone theory.

The third possible mode of response of the membrana tectoria to sound waves is that circumscribed areas in this membrane are thrown into vibration in different parts of the cochlea for tones of varying pitch. The tones highest in the scale would then produce vibrations in the tiny tectorial membrane found near the beginning of the basal coil, whereas the tones lower in the scale would produce response only in the larger tectorial membrane found in the upper coils of the cochlea. Circumscribed groups of hair cells in different parts of the cochlea would then be stimulated for each tone in the scale. This hypothesis accounts readily not only for the phenomena

of subjective tone analysis, but it offers the only plausible explanation for the occurrence of "tone islands" and of defects in the midst of the tone scale, as well as for the production of circumscribed areas of atrophy in the organ of Corti as the result of overstimulation by tones of a definite pitch.

The following conclusions, therefore, seem quite clear: First, that the membrana tectoria is the structure in the cochlea which by responding to the impulse of sound waves in the endolymph, brings about a stimulation of the hair cells of Corti's organ; second, that circumscribed areas in this membrane respond in different parts of the cochlea for tones of varying pitch, the high tones in the basil coil, the lower tones in the upper coils of the cochlea.

Such a response in the several parts of the membrana tectoria to the various tones in the scale is best accounted for, it seems, by the principle of physical resonance. The varying size of this membrane from one end of the cochlea to the other, and its complex fibrillar structure, are physical factors which suggest the basis for such a response. The actual demonstration by the construction of a model seems to be out of the question in a structure as delicate and as complicated as the membrana tectoria, especially since we are as yet unable to state what are the exact physical properties of this delicate structure. The fact that the explanation of the stimulation of the end organ in the cochlea is in the nature of an hypothesis that eludes actual demonstration, does not make the organ of Corti differ in this respect from other special sense organs. To expect of the physicist that he shall actually demonstrate just how the membrana tectoria fills the role of physical resonator is probably asking too much. It scarcely seems probable that the physicist with our present knowledge will be able to add anything that is much more tangible in the discussion of the problem of tone perception than has the chemist in the problem of color perception, nor should we expect that attempts to apply exact mathematics and physics in the explanation of the vibrations of the membrana tectoria would lead to any very profitable conclusions, at least until we are able to determine the exact physical character of this membrane. On the other hand, it should be recognized that the inability of the physicist to furnish us with an actual demonstration of the action of the membrana tectoria can hardly be construed as an

argument against the conclusions to which a logical discussion of this problem leads, namely, that circumscribed areas of the membrana tectoria respond in the several parts of the cochlea to tones of varying pitch, such a response being most readily accounted for, it seems, on the principle of physical resonance.

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LIX.

THE PRESENT STATUS OF LABYRINTHINE SURGERY.*

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Since 1895, when Jansen[1] first suggested the operative opening into the labyrinth to combat its purulent invasion, a great number of observations have accumulated, and many modifications of the operation on the labyrinth have been advocated. To Jansen, who led the way in surgical technic, and to Barany, who developed means of diagnosis, the profession is greatly indebted for whatever light has already been shed on this, the most obscure, insidious and baffling of all the complications of middle ear suppuration.

I intend avoiding more than a casual reference to the immense literature of this subject. Mostly recent, it is easily available, and I forbear the time and space which a thoroughly critical review of this side of the subject would entail. Personal observation necessarily must be of more interest, and in the hope of eliciting the experience of others with labyrinthitis, I present the present status of labyrinthine surgery from the personal standpoint.

To appreciate the basis of my remarks and comments, a very brief summary of my cases becomes necessary.

CASES.

Case I. Female, 27 years of age, came under observation (Manhattan Eye and Ear Hospital) August, 1906, suffering with an acute exacerbation of a chronic middle ear suppuration. Radical operation performed August 20, 1906.

August 22, 1906. Nausea, vomiting and rise of temperature, besides a feeling as if falling forward, accompanied by dizziness, are noted.

*Read at the fifteenth annual meeting of the American Academy of Ophthalmology and Oto-Laryngology, Cincinnati, September 19, 1910.

August 23. General condition better, but nervous irritability increased.

August 25. Horizontal nystagmus when eyes are turned toward healthy side, and later in the day, in addition, vertical nystagmus. P. 90, R. 22, T. 100.

Immediate exploratory operation. No fistula found, no erosion on semicirculars found.

At tip of petrosal pyramid, pus located communicating with an intradural abscess.

Patient grew rapidly worse and died 3½ hours after exploratory operation.

NOTE: Although there were symptoms from labyrinth, no external evidence on labyrinth wall was present to demonstrate that this was diseased.

CASE II. J. M., one year of age, came under observation at the Manhattan Eye and Ear Hospital March 27, 1907. Has otorrhea of three months' duration. Facial paralysis came on simultaneously with the otorrhea. Patient brought in semicomatose. Immediate radical mastoid operation, among the findings of which were necrosis of the dura; posterior bony meatal wall destroyed. The proximal end of the facial was not to be found. The distal end located embedded in granulation. Horizontal semicircular canal necrosed, and its lumen open (fistula).

April 2. Muscular spasm.

April 4. Vomiting, muscular spasm, nystagmus appeared.

April 6. Symptoms of meningitis clearly defined.

April 11. Death.

NOTE: The patient's general condition did not warrant a second surgical procedure.

CASE III. N. P., 1½ years of age, came under observation at the Manhattan Eye and Ear Hospital April 16, 1907, having a purulent otorrhea for one year. Fever had been present for three days. Radical mastoid operation April 18, 1907. Among the findings was an eroded horizontal semicircular canal.

The child was normal from April 19th to 23d, when a Panse flap was cut. The next day, after flap operation (April 24, 1907), temperature rose to 100.6, P. 150, R. 52, and facial paralysis became evident.

April 26. Child gradually became normal, and continued so until discharged from hospital, showing nothing unusual in

its postoperative condition except the facial paralysis, which was complete (May 2, 1907).

May 11. Patient was brought in with T. 103, R. 28, P. 28, in a semiconscious condition. Immediate exploratory operation on labyrinth was performed. The stapes was found imbedded in granulations, and when manipulated evoked no nystagmus. The entire labyrinth was opened and pus was found in all the internal ear channels. Lumbar puncture at the time of operation gave cloudy fluid.

From May 12th to May 18th, gradually grew worse until death intervened.

Note: No finding at primary operation to direct suspicion to labyrinth.

Case IV. F. S., aged 15 months, came under my observation at the Manhattan Eye and Ear Hospital suffering from acute purulent otitis media involving both ears. Immediate paracentesis.

June 10, 1907. The condition necessitated double simple mastoidectomy, which was performed on June 13, 1907. Case progressed uneventfully and was treated in the out patient department.

During the night of August 10-11 the child awoke with sudden attack of vomiting, accompanied with sudden facial paralysis on the right side, and was admitted to hospital the following morning with T. 103, R. 28, P. 130, facial paralysis and otorrhea on right side. Muscular twitching noticed in hands and arms. Pupils dilated, head drawn back, some convulsions immediately before operation.

Among the operative findings at the exploratory operation was stapes imbedded in granulations with perforated annular ligament. The labyrinth was opened completely (canals, vestibule, and cochlea). Facial nerve exposed.

Pressure on the jugular during operation caused increased flow of fluids from labyrinthine spaces.

August 13, 1907. Difference in size of pupils, the right larger than left, and patient died that day.

Note: Promptly opened labyrinth, which, however, proved unavailing. Increased flow of fluid when jugular was pressed upon, showing no protective barriers had been erected between local invasion and cranium.

Case V. Male, 37 years of age, came under observation at

the New York Nose, Throat and Lung Hospital December 31, 1908, suffering from a fulminating type of acute mastoiditis necessitating immediate operation.

Simple mastoidectomy was performed upon a very pneumatic mastoid process, no unusual findings being noted at the operation.

January 1, 1909. Vomiting, pain in head and ear and slight horizontal and oblique nystagmus noted toward the healthy side. On the afternoon of the second day patient had a chill, temperature rose to about 103, R. 28, P. 112. The temperature ranged from 102-103, R. 26-28, and P. 112-120, until January 4, 1909. Meanwile nystagmus had ceased, but sensation of dizziness continued. There was little or no vomiting, but meningeal signs became apparent, and on January 4, 1909, exploratory operation was undertaken. Among the findings we note that the horizontal semicircular canal was found eroded.

The pus from the mastoid process gave pneumococcus, as did also the lumbar puncture fluid.

Meningitis developed and patient died January 13, 1909.

Note: Operative proceedings were very limited upon the labyrinth, the eroded canal receiving attention only, because after the removal of the necrotic area nothing further abnormal was to be found.

Case VI. Patient, male, about 30 years, appeared at the Manhattan Eye and Ear Hospital February 26, 1910, with a fully developed mastoiditis in an ear which had been operated upon for acute mastoiditis many years previously. Simple mastoidectomy was performed, evacuating, in addition to the mastoid contents, a subperiosteal, a perisinus, and an epidural abscess. Noteworthy was the finding that this combined abscess formation was completely shut off from the aditus ad antrum and the antrum by a plate of smooth, hard bone, extending from the tegmen to the mastoid tip. The tip was found perforated through the diagastric fossa, and the abscess in the neck muscles was evacuated.

March 2, slight facial paralysis became evident (4 days after operation).

March 10. The wound was converted into a radical mastoid operation. The posterior bony meatal wall was found to be necrotic, and this came away in one piece. A fistula was found

leading into the horizontal semicircular canal. It was not curetted. Panse flap and suture, and uneventful recovery.

NOTE: Only symptom was a partial facial paralysis.

CASE VII. Young adult, 27 years, presenting symptoms of acute mastoiditis, was operated upon at the New York Red Cross Hospital, June 1, 1910. Simple mastoidectomy. The mastoid process was found to be partly sclerotic and partly broken down. Dura of middle cranial fossa exposed by disease, and also an area in the lateral sinus wall, far down near where it crosses under the meatal wall to enter the bulb.

Recovery was uneventful, except for the continuation of the otorrhea, the middle ear never being dry. The postauricular wound gradually healed, presenting at the time the patient left for home a rather broad sinus leading to the antrum. When this was washed through with medicinal solution, if the temperature was not carefully looked after, the patient underwent spells of dizziness and normally elicited nystagmus.

On August 29, 1910, he returned to me, presenting a depressed scar behind the ear, in the anterior part of which a small fistula was found leading toward the antrum. From this pus flowed freely, and he also presented a profuse otorrhea.

The patient had intense headache, considerable nausea, but no rise in temperature. Caloric reaction absolutely negative. Deafness marked, although exact fork tests were not made. Immediate radical operation was undertaken. Among the findings, pus was demonstrable in the canals of the bony meatal wall. Panse flap and suture of wound.

August 31, 1910. T. 103 +, R. 20, P. 88. This gradually dropped to normal on September 3, 1910.

September 1, 1910. Spontaneous nystagmus toward the diseased ear noted. This was more marked when lying on diseased side. Dizziness was complained of, also more marked when lying on the diseased side.

These symptoms gradually subsided, until on September 4, 1910, they disappeared, since when patient has steadily improved.

September 18. The fork tests showed lateralization toward diseased ear, but only the C^4 fork heard per air conduction.

NOTE: This patient was treated by absolute rest in darkened room for three weeks.

In addition to these cases, I have had quite a number of

others which presented all, or a certain proportion of the clinical signs of labyrinthitis, but in whom when on the operating table I was unable to demonstrate the slightest lesion in the outer capsule of the labyrinth. All of these cases recovered after the performance of the radical mastoid operation only. I omit reporting such cases in detail, because sufficient substantiation of recoveries in cases with such symptoms after this operation is found in the literature.

LABORATORY FINDINGS NO INDEX TO CHARACTER OF THE DISEASE.

The pathologic investigation of this lesion presents only one aspect to the observer. This, in a way, accounts for the unsettled status of the entire subject of labyrinthine disease. Invasion of the internal ear channels show upon microscopic examination that the various labyrinthine channels are either wholly or partially filled with purulent inflammatory exudate. This is associated with varying degrees of destructive inflammation of the membranous labyrinth. According to the stage of the disease when under examination, the findings will vary from simple hemorrhagic infiltrate to a complete flooding of the integral parts with pus; or the advancing evidence of caries or necrosis of the osseous structure is presented, in addition to those findings.

The microscope delivers the same sort of evidence, whether the purulent exudate in the internal ear is produced by an acute middle ear or a chronic middle ear suppuration, unless the given case is a chronic labyrinthitis *per se*.

It is, therefore, easy to understand the divergence in results obtained by surgeons who, although apparently dealing with identical conditions when considered from the laboratory standpoint, are often handling totally different infections from the clinical standpoint. The laboratory, in this instance, can give no idea of the virulence of the infection, nor the seriologic condition of the patient invaded. With these factors in mind, it seems advisable to rearrange our classification of the infectious labyrinthine invasions into the following groups, for differing operative indications will be found applicable to each group:

CLASSIFICATION OF LABYRINTHITIS.

1. Infectious labyrinthitis as sequela of acute middle ear disease.
2. Infectious labyrinthitis as sequela of acute exacerbation of chronic middle ear disease.
3. Traumatic labyrinthitis (hemorrhagic and infectious).
4. Infectious labyrinthitis following chronic middle ear disease (without acute exacerbation).
5. Chronic labyrinthitis.

For purposes of subsequent discussion, groups 1 and 2 and 4 and 5 are considered together.

To understand the present status of labyrinthine surgery, a brief discussion of the symptom complex and the indications for operation within these groups is in order.

SYMPTOMS.

Infectious labyrinthitis following the acute middle ear disease, and to a slightly modified degree those following the acute exacerbations of chronic middle ear disease, runs a typically characteristic course. In my cases its onset was usually very sudden, after the expiration of a varying interval of time following the primary operation or lesion in the middle ear. The onset is found to be marked with a distinct rise of temperature and the sudden appearance of facial paralysis. This controverts the opinion of Dench,[5] who does not hold facial paralysis an early or common sign of purulent labyrinthitis. The course of the disease is rapid, and one has hardly time to note the symptomatology significant of the labyrinthine lesion before the predominating signs of meningeal involvement supervene and obscure the clinical picture.

Whether the labyrinth was opened or not, in my case at least, surgical intervention was unavailing in all those distinctly the sequelae of acute otitis. All died. In this connection it is interesting to read Scheibe's[6] report that as many cases die as recover, irrespective of operation.

At first I ascribed the deaths as due to the poorer resistance which was offered by the children (my first few cases happening among children), but the other fatal case in this group (Case V), occurring in a young adult of the working class, previously always in good health, contradicted this idea.

A priori, it seems that these cases present data which justify a simultaneous surgical intervention upon the labyrinth at the time of the primary operation upon the middle ear. Yet in the light of experience with cases among children and adults —especially the former—in whom facial paralysis, high temperature and even symptoms of meningeal irritation, all have been found to subside after either simple or radical mastoid surgery (a not uncommon observation)—are we prepared immediately to exenterate the labyrinthine channels upon the meager data thus far at hand?

Answered affirmatively, and we will find ourselves very often needlessly opening into the labyrinth with consequent total loss of a functionating ear. For the present, at least, my viewpoint is that these cases should be treated palliatively, opening into the labyrinth only when definite signs of its involvement are at hand, and the loss of the fewer number of cases—for a great many of this minority of all the cases with meningeal signs will die—is compensated for by the safety of the many who will recover with a functionally active hearing apparatus under conservative treatment.

I may add, in passing, another observation. The study of the operative findings in the cases which evidenced distinct lesions—erosions of the semicircular canal, open labyrinthine window, etc.—at the secondary operation, where no such lesion was apparent at the primary operation, and where the outer labyrinthine capsule was certainly not under pressure of pus during the interval (the first operation laying the wall free), these cases demonstrate that the openings leading into the labyrinth found at the second procedure are not evidence that the pus worked itself inward to the internal ear channels from the tympanic spaces, but that it was evacuated from the labyrinthine interior in the usual effort of nature to rid itself of pus. This observation substantiates a conclusion of Richards[2], who finds that the outer labyrinthine wall will rupture sooner than the mesial one, given a purulent involvement of the labyrinth. The openings thus found at the second operation are to be regarded as points of eruption rather than gates of entry of purulent matter into the labyrinth.

In Case IV we note that during the performance of the operation on the labyrinth, after it was laid open, pressure exerted on the jugular produced an increased flow of laby-

rinthine fluids from the opened structures. This I interpret to mean that no obstructive barrier has been erected between the lymph and venous channels and those communicating with the internal ear spaces. In the rapid and virulent advance of the infection in the first 24 hours following after the first significant symptom, the way was still apparently open toward the cranium. In itself this characterizes the acute cases of labyrinthine infections. When we consider that the labyrinth is actually only a lymph channel which, through the development of the temporal bone, happens to be encased in bony walls, and incidentally only carries within itself the delicate end-organs of special nerves, then we must realize that its infectious invasion simulates the characteristic reactions of any other lymph channel in the body, and its inoculation by septic matter means rapid spread. The frequent implication of the jugular is a sign of this rapid spread of infection, as Richards has pointed out, when we consider the vascular connection between the veins of the vestibule, the semicirculars and the lateral sinus, and those of the cochlea and the inferior petrosal sinus. Therefore, surgical intervention must be most prompt and distinctly wide in scope if we hope to eradicate the infection.

The present status of our knowledge gives us no satisfactory indication to meet these requirements in time to avert the meningeal invasion which, once established, usually leads toward fatal outcome.

The existence of a difference between the purulent invasion of the labyrinth as sequela of acute and those following chronic middle ear cases is just beginning to receive some recognition abroad. Thus we find Jansen[4] stating that with acute otitis every vestibular disease is severe and dangerous, and every fistula in the semicircular canal is to be regarded as a sign of a present or imminent malady of the vestibular apparatus. Barany, Hinsberg and Scheibe[6] are of the impression that acute purulent labyrinthitis in acute ear cases more rapidly leads to meningitis than even the acute infections following chronic middle ear suppurations. Wanner[7] and Ruttin[6] also make distinctions between the two conditions, while Neumann[6], on the other hand, from his pathologic studies, is disinclined to accept the existence of these differences.

DIAGNOSIS OF ACUTE LABYRINTHITIS.

What means have we for diagnosing acute purulent labyrinthitis following acute infections of the middle ear spaces?

My cases, as well as a large proportion of those recorded in the literature, never give any sign characteristic of the class of case under discussion until meningitis is present.

Fever, headache, nausea and vomiting constitute no significant symptoms. The special signs from the labyrinth, such as tinnitus, are rare, and cannot be obtained at all from children. The estimation of impaired hearing also presents difficulties, because of the condition of the patient's faculties after the onset of labyrinthine infection, nor is it in any way characteristic of the lesion.

It is conceded that tuning fork tests are of doubtful value. (L. Page[10].) In children, totally useless; in adults who are still in possession of their faculties the following is found: Bone conduction is usually impaired, and range of audition greatly reduced; the upper tone limit lowered, and the lower tone limit elevated. Richards[2] also found the fork tests of no value. In themselves, these findings are not significant.

On the other hand, if deafness develops under our eye, if we witness the sudden change in lateralization and the gradual lifting of the lower tone limit and the descent of the upper tone limit, in conjunction with loss of hearing for language, then and only then will the estimation of impaired hearing have any significance.

The estimation of disturbance of equilibrium is subjected to the same general criticism as applies to the hearing tests. It is not significant of labyrinthine trouble.

SPONTANEOUS NYSTAGMUS.

Spontaneous nystagmus seems the only significant symptom, and it too often comes on too late to be utilized as a factor of surgical moment. In four of my cases it was present. In one it appeared seven days after onset, in another five days, in the third case it appeared on the second day, and in the other it presented itself four days after the first operation.

Shall the appearance of spontaneous nystagmus be our guide to operation? Barany says that if spontaneous nystagmus undergoes rapid decline it points to the labyrinth. If it per-

sists unchanged for several days it points to cerebellar disease. If it remains unchanged but strongly marked for 24 hours it originates probably in an endocranial abscess. My cases do not bear out this interpretation. MacKenzie[9] in discussion at the Otological Section of the British Medical Association warned against relying on the evidence of spontaneous nystagmus for diagnostic purposes. Like vertigo, he considers it a danger signal only, and we know that like vertigo it may be provoked by many other conditions besides labyrinthine involvement.

Nor can the direction of the spontaneous nystagmus be made of diagnostic import. In my cases its direction varied individually, and MacKenzie's[12] studies likewise demonstrated variability in the direction of the spontaneous nystagmus in the same class of cases.

By examination, we can test co-ordination (v. Stein), and we also have the vestibular tests of Barany. The former are almost impracticable of application, and the value of the latter is a debatable subject, in the type of case we are discussing.

CALORIC REACTION.

Since the introduction of the Barany caloric reaction something has been accomplished toward diagnosis of labyrinthitis. The test is simple in application, it supersedes the rotation tests and is fairly accurate in its significance. But in the acute infectious labyrinthine diseases it has many disadvantages which must give us thought.

Barany[9] recently stated that the vestibular tests are not sufficiently delicate to enable us to diagnose trifling diseases in the labyrinth; nor do they at any time, for that matter, enable us to determine what kind of pathologic changes are being enacted within the labyrinth. The test then fails when most needed to give timely warning that surgical intervention is indicated. Jansen[4] holds that the caloric reaction has often not disappeared at the precise time when the surgeon would have the most favorable situation in which to operate.

Furthermore the caloric reaction is of no value in cases where vertigo is pronounced and when it is only present when the patient is turned toward the diseased side (Jansen[1]). In Case VII of my series this was the finding. The caloric reaction was absolutely absent, yet the patient made a full re-

covery without operation. Jansen, in addition, reports that the inflammation may reach the brain before loss of vestibular function is manifest. Comparing his observations at the operating table and those from autopsy, in cases both with positive (i. e., elicited nystagmus) and with negative (loss of functional activity), he believes that only the negative finding has value, for he found with a "well conserved reaction"—to use his own words—cases of severe inflammatory alterations in both vestibule and semicircular canals, which often led to fatal meningitis.

Finally, as Lermoyez and Hautant[11] have shown, the caloric reaction only gives information regarding the functional activity of the posterior labyrinth exclusively.

DANGERS OF CALORIC TEST.

Finally not only is the caloric test of doubtful diagnostic value, but its performance, in the acute type of cases we are discussing, entails certain dangers. I have therefore not tried it on my cases except in Case VII, and here only before I really comprehended the patient's condition. My reasons for this attitude are based upon observations which Richards and others have made, and substantiation through my own findings, to which I have already referred when discussing fistulæ and erosion on the outer capsular wall of the labyrinth, as being evidence of efforts at evacuation of purulent products from within the labyrinth outward, rather than signs of inroads of pus toward the endocranium. To syringe even sterile water into the middle ear, as must be done (because the tympanic cavity is laid open by virtue of the radical operation), naturally creates back pressure on the pus contained in the labyrinthine channels, and to anyone who has taken the trouble to examine specimens of circumscribed labyrinthitis under the microscope, the delicacy of the protecting barriers which nature throws around the labyrinthine invasion must be evident. It requires but little additional force to break these up and thus disseminate the infection, and change what we hope may turn out to be a localized lesion into one which will be diffuse.

Scheibe[6] likewise finds reasons to omit using the caloric tests, believing them distributors of infection within the middle ear channels in this class of cases. Aside from the possibility of causing part of the water to penetrate the labyrinth

through a possibly open labyrinthine fenestra, he holds that the movements of the intralabyrinthine fluids which, according to Barany and others is necessarily provoked by the tests, that these movements are not to be considered in this connection indifferently. Finally Jansen[4] states his belief that "syringing" (caloric testing) should be avoided as long as we hope for a favorable or spontaneous cure of the case.

From all the above, it follows that absolute diagnosis or even probable diagnosis with the present means at our command is impossible before exploratory operation, and secondary exploratory operation is justifiable only when the entire clinical aspect of the case is studied, and when this warns us that meningeal invasion is threatening. Until the signs of meningeal irritation supervene, that is, signs of irritability from the arachnoid membrane, we have no indication for exploration of the labyrinth. This conservative attitude has the endorsement from clinical experience of Uffenorde,[14] Marx,[15] Gradenigo,[16] Scheibe,[6] Panse,[6] Schwartze[6] and others. Hinsberg,[6] in fact, adds that he believes the opening of the labyrinth in acute labyrinthine invasions in the course of acute otitic cases, a short time after rupture, to be a measure in itself not devoid of danger, and Barany, too, believes that in the absence of danger signs, a certain time may be allowed to elapse before operating, in analogy with the late operations in appendicitis.

Given a case with suspicious symptoms, after acute mastoiditis or following an acute exacerbation of a chronic purulent otitis, of what shall our treatment consist? I believe that Scheibe[6] has found the rational answer. The therapy consists in absolute rest, after the eradication of the primary foci in the middle ear spaces. He employed this method in four cases. The patients were kept almost immovable in bed for at least three weeks. He had one fatal termination, and in this case absolute bed rest was not enforced. He reports that in comparison with these uniformly good results, his results when he still treated labyrinthine suppuration as ambulatory cases were a uniformly fatal termination. Since all my previous cases with marked symptoms had died, whether operated on or not, I tried this method in Case VII, and can report my first recovery where labyrinthitis was distinctly diagnosed in the course of an acute middle ear infection. During

the rest period, the patient must be faithfully watched for meningeal symptoms, at the first sign of which operative intervention is urgently demanded.

Then prompt, radical surgical measures become the order of the day. Any hesitancy on the part of the surgeon, or in completeness in technic not only affords no advantage; it usually does harm. For, as Urbanschitsch[13] remarks, although the unfavorable course of meningitis cannot be arrested in the majority of the cases, nevertheless the timely operation on the labyrinth may prove successful, even in the presence of meningitis so far advanced as to give turbid or purulent fluid upon spinal puncture.

SURGERY OF ACUTE LABYRINTHITIS.

Regarding the surgery of this type of case, it is to be remembered that none of all the advocated surgical procedures completely meets the surgical requirements of the lesion. It is not possible to reach those cases where infection is present in the intricate cellular system at the pyramidal tip. Such cases cannot be controlled by operation, according to Winckler[6] and others. Laurant[17] also acknowledges the impossibility of obtaining complete elimination of pus foci. Time in performing the various technical procedures is an unfavorable factor, and it takes time and care to do the advocated procedures to totally expose the various semicircular canals combined with an extensive vestibulotomy and full exposure of the cochlea whorl.

The simplest procedure, and in my opinion the quickest performed, and the only one which meets all the surgical indications in these acute cases, is the total ablation of the petrosal pyramid with its contained labyrinth. This presents certain distinct advantages. The advantages reside therein that it eradicates the entire mass of infected cellular elements at the tip, including the entire labyrinth. It drains the posterior cranial fossa (the usual site of first infection of the endocranium) at its most naturally placed drainage point—at the location of the internal auditory meatus. The middle cranial dura is likewise rendered accessible. On the other hand, the dura is attached closely to the pyramidal tip, and conceivably might be torn in removing the bone. The petrosal sinuses are also liable to injury, but both these disadvantages very often

obtain during the performance of the Jansen-Neumann method of the labyrinthine operation. Finally, the proposed procedure entirely sacrifices the facial nerve.

I regard the class of cases in which the total extirpation of the petrosal pyramid would be indicated as most desperate, and it hardly seems to me to be a correct surgical attitude to permit a nerve (even as important a nerve as the facial nerve) to stand in the way of total removal of all accessible portions of the diseased ear.

Whether or not the profession is ready to take this stand in regard to sacrificing the facial, in the face of these desperate cases, I do not know. Gradenigo[10] only has even touched on this side of the subject, but I firmly believe that, in the face of almost universal fatal outcome of these acute cases of purulent labyrinthitis, the preservation of the facial nerve should not enter into consideration, and it is the conservation of the contiguity of this nerve which makes the various advocated labyrinthine operations difficult in technic and slow in their performance.

In conclusion, I may add that there are two absolutely indispensable conditions for success in labyrinthine surgery, no matter which procedure is selected, and these are that the labyrinthine interior must be made as accessible as possible to the surgeon, and he must thoroughly understand the surgical topography of these regions.

TRAUMATIC LABYRINTHITIS PURULENTA.

Under the heading of traumatic labyrinthitis, I group those lesions of the labyrinth which are the result of accidental injury, either extraneous or of surgical origin.* The condition is rather rare from both sources. The protected position of the internal ear accounts for the rarity in the first instance, and a better understanding of the surgical technic of the radical mastoid operation mitigates the frequency of injury in the second instance. The horizontal semicircular canal is most frequently the location of the lesion (Jansen[4]). The next most usual site of the trouble is the accidental luxation

*The term "postoperative labyrinthitis" of Jansen, Alexander, Hinsberg and others is misleading. What they refer to is really a latent labyrinthitis observed in connection with chronic middle ear disease which becomes manifest after radical mastoid surgery.

of the stapes. The latter constitutes the more serious of the two injuries. I do not consider the accidental opening of the horizontal canal as possessing great factors of danger. The small size of its lumen and its readiness to occlusion in the face of inflammatory reaction soon places protecting barriers against the further propagation of infection. Furthermore, the absence of any communication between the semicircular canals and the cranium are likewise factors of safety.

When luxation of the stapes takes place the immediate access which it permits to the vestibule constitutes its danger. However, many cases are recorded which never progressed toward a general labyrinthine infection. When infection does, however, supervene, its onset is sudden. Within a day—according to Jansen, half a day—symptoms appear which are mostly unappreciated as to their significance, because the patient is still battling with the after-effects of his necrosis (Mygind[18]). The onset is manifest by vertigo, disturbance of equilibrium and nystagmus, and occasionally by a subjective sensation of tinnitus. By a careful observation of the case, the rise in temperature, headache, and the above mentioned symptoms make its diagnosis clear.

The differential diagnosis between traumatic infectious labyrinthitis and labyrinthine irritation cannot be definitely made, except by a consideration of the case as a whole. We interpret continued rise of pulse and temperature as significant of arachnoidal reaction, and its presence clears the diagnosis.

The infected cases naturally simulate the condition which I have described under the discusison of acute infectious labyrinthitis following acute middle ear disease, except in so far as we know the route of invasion in the traumatic cases.

In dealing with this condition, prophylactic measures are better than cure. It is a good practice, when performing the radical mastoid operation, to have the anesthetist not only watch the face for twitches from the facial during the removal of the posterior bony meatal wall, but also to watch the eyes for signs of elicited nystagmus during the removal of the two greater ossicles, and during the cleansing of the tympanic cavity. The slightest touch on the stapes will evidence itself by nystagmus, and will warn the surgeon in time. Likewise when performing the radical operation, if areas of the outer labyrinthine capsule look suspicious, or superficial erosions are

noted on the arches of the semicircular or upon the promontory, or when granulations are crowded about the oval window, do not remove them, they are as much protection barriers here as are the granulations situated upon the uncovered sinus in cases of perisinus abscess. Gradenigo even considers it dangerous to remove cicatricial tissue from the labyrinthine walls.

TREATMENT.

Given a suspected case of traumatic injury, at once remove all dressings, and inspect the labyrinthine capsule. Then wait and keep patient absolutely at rest. Operative intervention becomes indicated as soon as symptoms of labyrinthine infection are marked, persistent or on the increase. Jansen believes in early operation on these infected cases, because from his observations at autopsy compared with those at operation on similar cases, he finds that the operative procedures do not hasten death. Because only two of his cases showed spontaneous cure, he believes it better to open the infected part than to wait for labyrinthine symptoms to increase or diminish. When we operate early a favorable outcome is to be anticipated.

When operating on these cases, the opened labyrinth should not be curetted, so as not to detach any adhesions which may have formed with the meninges. (Boenninghaus.[21])

LABYRINTHITIS CHRONICA.

The continued presence of a chronic middle ear suppuration, if permitted to run its course unchecked, eventually in a certain proportion of cases, invades the labyrinthine channels. The primary site of penetration toward the interior is a matter of controversy, but really is of little practical importance. Within the labyrinth, the invasion either spreads throughout the internal ear channels, or it becomes localized to a given part. It represents in the majority of cases the connecting link between chronic middle ear suppuration and fatal endocranial complications (Rendu[19]).

Its course is characterized by a period of latency, of varying intervals of time, which sooner or later becomes actively manifest as a purulent infection.

DIAGNOSIS.

The diagnosis of serous labyrinthitis and circumscribed labyrinthitis are both open to question. From both conditions recovery may take place, and the tendency to describe all recovered cases (without operation) as circumscribed lesions is naturally inaccurate, for we have no positive methods of localization, and in the second place, the so-called cured cases of either type rarely come to intelligent autopsy examination. For the present, at least, we can designate this type of labyrinthitis under two groups only: (1) Chronic latent labyrinthitis; (2) chronic manifest labyrinthitis.

Regarding diagnosis, it is to be marked that pronounced or well defined signs of labyrinthine suppuration are rarely present, except in the cases of sudden invasion or rapid extension. This lesion rarely falls within this compass. Conceivably, when the process or erosion advances slowly, gradual accommodation of the vestibular function to the changed situation ensues, so that manifest symptoms are not always observable. (L. Page.) In a large percentage of cases the labyrinth is destroyed without characteristic symptoms.

The latent period in these cases is the most difficult, not only to diagnose, but it also presents difficulties for the formulation of operative indications. According to Rendu,[19] the disease is most frequently expressed by paralysis of the vestibulocochlear nerve, i. e., deafness for air and bone conduction, loss of vestibular reaction to rotatory and caloric tests. The most valuable data for diagnostic purposes are obtained from careful functional tests, the history of the case, and the study of the symptoms accompanying the chronic otitis.

Transient attacks of dizziness and vertigo are suspicious; the operative findings at the radical mastoid operation, presence of fistula—all give presumptive evidence toward labyrinthine disease. Schmiegelow[20] opens the labyrinth in these cases, when one or more fistulæ are present. He does not operate on the labyrinth when it presents an isolated fistula in the semicircular canal and the hearing is good.

When functional examination points toward labyrinthine disease, but the findings at the radical operation are negative—no fistula, and semicircular canals are not even darkened—it is advisable to wait an interval before operating, for while labyrinthitis may be present, it may already be on the road

toward encapsulation (Boenninghaus). When there are merely signs of labyrinthine irritation at the time of the operation on the middle ear, neither necrosis nor orifices being discernible, the opening of the labyrinth is not indicated. In this case, as well as in those where erosions are present, with or without labyrinthine symptoms, it is a good rule to keep patient under observation for some time.

Laurant[17] believes in curetting and disinfecting the local erosion or fistula, Gradenigo[16] strongly takes the opposite view, and Politzer goes even further in warning against the removal of granulations about a fistulous opening. MacCuen Smith[22] holds that a large majority of the fatal cases have occurred as the result of meddlesome surgery, which disturbed the protective barriers erected to prevent infection being carried to the meninges and the interior of the skull. West and Scott[23] operate in all cases wherein the vestibule and the ampullary extremities of the canal are involved. In fistula or necrosis of the external bend of the outer canal, and in the absence of all labyrinthine symptoms, they hold that the operator may limit himself to a simple curettage. When promontory or cochlea is found perforated, the diseased bone should be removed. In lesions of the semicircular canals Richards limits operative procedures to carious areas found.

The recommendation of expectant measures in circumscribed affections of the semicircular canals is based on the assumption expressed by Hinsberg, Jansen,[4] Bezold, Bourguet[28] and others, that this form of labyrinthitis frequently heals together with the middle ear and very rarely becomes the starting point for fatal complications.

The contraindications to the operative opening of the labyrinth are essentially based upon the fact—shown by pathologic anatomy and clinical experience—that in a certain proportion of labyrinthine suppurations, which are limited to segments of the labyrinth—protective adhesions form and prevent the propagation of the infection, thus permitting spontaneous healing. Interference is therefore unnecessary and even dangerous in these cases. The complete and rapid removal of the cause of the inflammation is all that is indicated (Gradenigo).

Let us now consider cases where there are marked symptoms suggesting labyrinthine involvement. My views coincide with those of Jansen, Hinsberg and others, that these

symptoms often all disappear with the performance of the radical mastoid operation. Of 190 cases which Jansen considered as being "decidedly labyrinthitis," there were only ten which proved fatal. In all of the 190 cases radical mastoidectomy only was performed. From this he believes that we have acquired evidence, at least regarding the vestibular portion of the labyrinth, that a great number of cases do not end fatally, nor in chronic ailment, but effect a spontaneous cure. In his opinion there is not the slightest doubt that in the majority of these cases disease of the entire vestibular portion of the labyrinth has been present, even though single or numerous instances of it may be regarded as a circumscribed disease of the semicircular canal.* On the other hand, operation should be undertaken upon the labyrinth at the first definite sign of the progression of the lesion, and this must be determined by careful observation of the patient, studious estimation of the various functional tests, and the operative findings at the primary operation. When hearing is markedly impaired, caloric reaction is negative; if fever, vertigo and headache are present it is safer to operate than not to operate.

Summarizing the indications for operations on the labyrinth we contend:—

1. That the indications for opening the labyrinth in acute infectious labyrinthitis following acute middle ear suppurations, and following acute exacerbations of chronic middle ear suppurations, are still a debatable question. If operation is elected, then it must be extremely extensive in area, and promptly follow the first sign of meningeal irritation. That

*The suppurative affections of the labyrinth which heal spontaneously include: (1) Cases of labyrinth suppuration occurring in the course of a purulent cerebrospinal meningitis, the middle ear remaining intact; (2) otitic purulent labyrinthitis, in which an abscess forms in the labyrinth as the result of suppuration of the membranous labyrinth, whereas the bony labyrinth and the petrous bone are not involved in the inflammation; (3) cases of purulent labyrinthitis in which the bony lateral wall of the labyrinth is first affected by way of the middle ear, and the pus at last ruptures into the labyrinth through a fistula, the remainder of the labyrinth remaining normal. Needless to say that recovery takes place at the expense of the nerve end organ terminals. (Deafness and total loss of irritability of vestibular and semicircular apparatus in the majority of cases. In the minority of cases, a remnant of hearing and a positive reaction to irritability of the semicircular and vestibular apparatus are left behind.) (Alexander) (25).

in this class of case no reliance should be placed upon data from functional examination.

2. When labyrinthine suppuration appears as the sequela of chronic middle ear suppurations, or cholesteatoma, without demonstrable disease of the labyrinth, then operation may be limited to the middle ear spaces, a retrogression of the labyrinthine symptoms being within the range of possibility. Fistulæ of the semicirculars, and erosions of the promontory, in cases with intact hearing, do not require operative intervention. When symptoms of labyrinthine involvement appear in the course of suppurative middle ear disease, or after operations on the middle ear, without fever, and without signs of meningeal irritation, then an exact functional examination to determine the activity of the labyrinth is first demanded. If found functionally active, but of less intensity in reaction, no immediate labyrinthine operation is necessary, although surgery may become a necessity at a subsequent period. If function is totally lost, then prompt operation on the labyrinth, opening it extensively, is indicated to guard against meningitis.

REMARKS ON TECHNIC.

The many operations which have been published and advocated by various authorities are evidence in themselves that no one given method of procedure meets the surgical requirements of purulent labyrinthitis.

The situation should be met by individualization necessitated by the conditions found in the given case.

I do not intend detailing the various operative procedures advocated from so many different sides. They really differ more in regard to technical details than regarding fundamentals. Personally I prefer the Richards operation,[2] and when I have the choice, that procedure is employed in my cases.

In the interest of completeness, I will add the following remarks on technical points:

The Richards operation starts by entering the labyrinth behind the facial ridge. The semicirculars are thus opened from behind, the facial nerve is conserved, then the vestibule and finally the cochlea is opened. The posterior cranial fossa is not opened as a step in the labyrinthine surgery.

The Jansen-Neumann method opens the posterior cranial fossa as part of the procedures on the labyrinth. It guaran-

tees the complete suppression of deep-seated diseased bone segments, from which endocranial complications may start. Furthermore, it permits an easy exploration of the posterior and middle cranial fossa. This operation is very radical, dura is exposed to a great extent, and this very exposure interferes with the progress of the operation by producing sagging into the wound during the operation and during the after-treatment. Rendu[19] finds it impossible to curette the anterior and inner portions of the labyrinth on this account. Gradenigo holds the Jansen-Neumann method too aggressive. Jansen, however, considers his operation especially adapted to cases where endocranial complications exist, and Neumann thinks it preferable to expose the cranial fossa at once for both diagnostic and operative purposes.

The method of Hinsberg,[27] Bourguet[28] and Botey[29] are similar. They, however, reach the vestibule from in front of the facial ridge, then enter the promontory, etc. This method of procedure leaves a blind pocket—a cul-de-sac—at the lower orifice of the semicircular canal, besides greatly endangering the facial nerve. Jansen[7] and Frey[7] regard the procedure as dangerous.

Uffenorde's operation[14] and its modification by Bourguet endangers the facial nerve, besides being one of the most complicated technical procedures.

Hautant[30] proceeds in a manner similar to Hinsberg, and after the vestibule is opened the end of the external semicircular canal is exposed. He follows the deeply lying branch of this canal until it reaches the vestibule, thus opening from in front and from below. He then individualizes the subsequent procedures according to the findings at operation. Dura of the posterior cranial fossa is not exposed in the face of the endocranial complications.

The method of Hammerschlag and Frey[31] is particularly fitted for cases where the lateral sinus is situated far back, according to Neumann.

These constitute the most commonly known of the various operations on the labyrinth. With the requisite knowledge of the topographic anatomy and a working technic in any one of these procedures, the varying details of these operations are easily at hand for anyone, and their respective values can be individually established.

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LX.

CONCERNING THE CAPSULATED BACTERIA IN THE PRODUCTION OF ACUTE MIDDLE EAR AFFECTIONS.

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The part that the capsulated bacteria (pneumococcus, Friedländer bacillus, streptococcus mucosus) play in the production of acute middle ear suppuration and their complications has been pretty thoroughly worked out in the last few years and is of enough importance to warrant a review. Of the three, the Friedländer bacillus seems to be least frequently observed, the streptococcus mucosus the most often. As regards age, the pneumococcus is more frequently found in children, the streptococcus in adults.

Netter,[1] in 1887, found the pneumococcus in the labyrinthine fluid in a case that had died of meningitis, and in the same year Zaufal[2] isolated the Friedländer bacillus and again the diplococcus pneumoniæ, Fränkel-Weichselbaum, in two cases of acute middle ear suppuration. In June of the same year Dr. Emil Pins, of Vienna, pointed out the possibility of the Friedländer bacillus passing up the eustachian tube and producing a middle ear suppuration in children. Zaufal, Netter and Weichselbaum, in 1889, agreed that the pneumococcus was capable at least of producing the otitic complications. From this time on many observations appeared on the influence of the pneumococcus in acute middle ear affections, which were summed up by Leutert,[3] in 1899, when he said that the pneumococcus is the more mild cause of acute affections, on account of the facts that the pus ceased earlier, there is a lower temperature, the findings at operation are smaller, and

there is a shorter after-treatment necessary than in those due to other bacteria; however, the pneumococcus has more of a tendency to pass from antrum to periphery, leaving but little destruction of the septa, and the active pyemic process lies more in the periphery of the mastoid at the time of operation, whereas the streptococcus has more of a tendency to break everything down as it advances. The pneumococcus cases have more of a tendency also to remain latent for some time after the acute infection, and later show a tendency to acute recurrent attacks in the mastoid.

Concerning the question of priority in the discovery of the streptococcus mucosus capsulatus there is much uncertainty; suffice it to say that before Schottmueller's work appeared in 1903 there had been organisms isolated from various sources that clearly resembled his, namely, by Knuth,[4] 1895; Seitz,[5] 1896; Binaghi,[5] 1897; Weinberg,[7] 1899; Bonome,[8] 1890; Lewcowitz,[9] Richardson,[10] and Howard and Perkins,[11] 1901, and Longcope,[12] 1902. Of these, those of Bonome and of Howard and Perkins seem to be most certainly the same organism. As the cause of otitic meningitis, Schottmueller found it in 1899, and subsequently in two other cases, 1900, 1902.

In the United States, Howard and Perkins, 1901; Longcope, 1902, and Burger,[13] 1905, all got the streptococcus mucosus, which they describe, from cases of otitic complications.

Schottmueller,[14] in summing up his findings in the three cases of meningitis, in 1903, says that it is interesting to note that in each of the cases (1) the meningitis was following an acute otitis; (2) the bone was relatively rapidly necrosed; (3) the drum membrane showed a remarkably small amount of pathology. The meningitis in all three cases progressed very rapidly, with severe symptoms and high fever, to death within a week. Heims[15] isolated the streptococcus mucosus from the ear in pure culture, and in 1904 described a case of middle ear suppuration in which the roof of the antrum and the zygomatic process were necrotic, and from the pus of which Rosenthal isolated the same organism.

In 1907,[16] at the Congress of the German Otological Society, Kummel read a referat on the bacteriology of acute middle ear disease, in which he analyzed the work of Supfle, and was followed by papers by Denker,[17] Kobrak,[18] Neumann and Ruttin,[19] and Wittmack,[20] in which Supfle, taking

the bacteria from the middle ear, found a percentage occurrence of the mucosus, 13.95; of the pneumococcus, 18.61; and Denker, taking them from the mastoid at operation found a percentage of mucosus, 13.87, and pneumococcus, 0.

Kummel observed, as Schottmueller had, that the streptococcus mucosus produces the late manifestations even after the healing of the acute otitis, and Kobrak, in his excellent paper, summed up the differences clinically by saying that where the streptococcus longus produces the protracted (pyemic, septic) form, the pneumococcus produces the cyclic, and the streptococcus mucosus the interval forms, the latter showing no continual course between the acute attack and the complication period, but a more or less free interval and a tendency for the primary focus to heal after the primary attack, or a few repeated acute exacerbations, while the process continues often latent in the immediate surroundings. Wittmack gave the percentage of mucosus cases which leads to complications as 75, and added that in children it is much less frequently seen than the erysipelatous forms, these being secondary to scarlet fever, measles, angina, arthritic rheumatism, etc., whereas, the mucosus forms are more often primary, possibly (with a great question) following pneumonia in rhinitis.

Neumann and Ruttin found out of 24 cases of streptococcus mucosus that 22 came to operation, and only two healed spontaneously. They hold with Politzer that the presence of an acute mastoiditis is more dependent upon the anatomic structure of the mastoid rather than upon the form of bacterial infection; that is, that the pneumatic form of mastoid has a predisposition to encourage the growth of bacteria. On the other hand, the course of the disease is dependent more on the form of bacteria, the capsulated bacteria producing one type and the noncapsulated another.

To differentiate clinically, they say, the bacteria within each individual group is difficult, still the streptococcus mucosus cases present a certain group of symptoms which are fairly constant, namely (1) an isolation of the inflammatory process in the middle ear in the first or second week; (2) the remaining of a marked disturbance of hearing and constant subjective noises; (3) a drum membrane that reminds one of a secretory catarrh, showing a moist, pale, dull, reddish color, the details

recognizable, but the sharpness of outline obscure and the light reflex not well marked. There is no earache and but little tenderness to pressure over the mastoid, and then only in small areas. A paracentesis gives a mucous or mucopurulent exudate. The disease keeps this picture until the advancing destruction of bone has produced a complication that is dangerous to the life of the patient, or has made itself manifest externally. The symptoms are, as a rule, so mild that the patients often come first to the physician with a well-marked perisinous or extradural abscess, or even a meningitis, and then the history is brought out that the dull, indefinite aching in the ear region and partial deafness have been present for weeks or months.

The latest work on the subject has been recently published by Dr. L. Artz,[21] who states that of seven otogenic pyemic meningitis cases which came to autopsy at the Policlinic Hospital in the last year, 3, or 43 per cent, were due to the streptococcus mucosus.

The following three cases, which have been observed at the Urbantschitsch Clinic in the last few months, will illustrate the course of the disease due to the capsulated bacteria:

Case I. W. S., twenty-five years. For eight weeks a slight left-sided earache and discharge following an acute rhinitis. No dizziness, no fever. For the last four days the discharge had ceased. The upper anterior portion of the external canal was slightly reddened and sunken, the drum membrane was swollen slightly in the upper half, the lower half was clear, no secretion, no perforation. Mastoid tender to pressure over the tip. Operation: The mastoid cells were red, filled with granulations, but no pus. The general appearance was that of a healing mastoiditis. The operation was considered finished when a small area of granulations was noticed near the middle of the sinus region. This marked an erosion in the bone which allowed a small curette to pass into a large area of granulation tissue, covering the lower half of the sinus and the bulb. On removing the bone from over the sinus a large peribulbar abscess was entered. Bacteriologic findings: Pneumococcus. In this case the process in the middle ear and mastoid had become so quiescent that the advisability of an operation at all was in doubt, and were it not that the cause was evidently a capsulated bacterium, the case

would not have been operated until there had developed a sinus thrombosis or other more serious complication.

Case II. A. S., twenty-nine years. Twelve weeks previously sudden pain in the left ear. This became less in a couple of days, but never entirely disappeared. A slight suppuration continued until four days before admission to the hospital. There was some dizziness, no nausea, no fever. On entrance a mild occipital headache was present. Left external auditory canal somewhat swollen; drum membrane pale red and bulging; central perforation; pulsating pus at the bottom of the canal; superior posterior portion of the bony external canal sunken. No tenderness over the mastoid. Operation: The mastoid presented a hard, thick cortex, with a medullary portion that showed a softening which reached well under the auditory canal and back to the sinus, from the knee to the bulb. The sinus was covered with the hard cortex still, so that the process had produced an undermining and a perisinous abscess. There was but little pus present and the amount of granulation tissue increased from antrum to sinus, so that the most active part of the process was close up to the sinus. Bacteriologic report: Streptococcus mucosus.

Case III. J. L., aged thiry. Admitted April 12, 1910. Six weeks previously patient had had a sudden double-sided earache, which lasted in a mild form for four weeks. The discharge began four days after the initial attack and continued also for four weeks. Fourteen days before entrance there was a tenderness behind the left ear. There was a slight headache, no dizziness, no nausea. Temperature on entrance, 38.4° C. Drum membrane pale red, bulging, details not recognizable, no perforation, no discharge, sinking of the posterior superior external bony canal, mastoid process tender to pressure. Operation: Opening of the antrum. At the first stroke of the chisel a large quantity of pus appeared under heavy pressure. The sinus was laid free from knee to bulb. The abscess was continuous with a Bezold's abscess, which reached to the base of the skull, and which had broken through from the tip of the mastoid. During the operation, which was performed by one of the aspirants of the clinic, there was an injury to the sinus. From the twelfth of April to the eighteenth of May the patient had a normal after-treatment. On the eighteenth I saw the patient at 11 a. m.; the wound was nearly

closed to the surface of the skin with healthy granulations. The drum membrane nearly normal; no tenderness over the ear region. There was a dull left-sided headache, which the patient had noticed for two days; pulse normal; wound was dressed and patient discharged. He was brought in at 6 p. m. on the same day by the emergency service, unconscious, with restlessness and stiffness of the neck; reflexes present; corneal hyperesthesia; no nystagmus; pulse 92. He had been aphasic in the afternoon. Lumbar puncture gave a cloudy greenish-yellow spinal fluid, which came out under high pressure, and on standing left a fibrin coagulum. Diagnosis: Meningitis. Operation: Nothing abnormal was found in the wound or in the meninges at the site of the operation, and no brain abscess. Bacteriologic report from the spinal fluid: Pure culture of streptococcus mucosus. Autopsy: Diffuse streptoleptomeningitis; small dural hemorrhage; small thrombus at the beginning of the sinus longitudinalis. Lobar pneumonia in the left lower lobe. Atrophic cirrhosis of the liver; chronic splenic tumor; chronic perisplenitis; parenchymatous degeneration of heart and kidneys.

The sudden appearance of the meningitis over a month after the original operation, and three months after the primary acute attack, at a time when everything was quiescent, the short duration of the meningitis and the severe symptoms are all characteristic of the streptococcus mucosus.

The prognostic value of the diagnosis of the capsulated bacteria in acute middle ear affections is of the utmost value, as no case due to these bacteria should be allowed to pass from the physician's care until all possibility of a complication is gone, and at the least indication operative interference is justifiable. If in the course of treatment the capsulated bacteria are found, the physician should be prepared for a long siege of waiting and careful observation, and the relatives should be warned of the danger of complications, in order to insure an early operation should symptoms indicate.

For permission to publish these cases I am indebted to Professor Dr. Urbantschitsch and Assistant Dr. Ruttin, of the K. K. Universitats Ohrenklinic, Vienna, to whom I wish here to express my thanks.

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LXI.

THE ANATOMIC EXPLANATION OF VESTIBULAR NYSTAGMUS.

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As a result of the admirable work done by Barany and others in Vienna during the last five years, numerous articles dealing with the clinical significance of nystagmus have been published. Other than the mere statement that the two vestibular apparatuses normally exert, through the vestibular nerves, a certain influence over the nuclei of the eye muscle nerves, and that a disturbance in the equilibrium of this influence results in nystagmus, little has been written concerning the actual anatomic explanation of the phenomenon. For this reason, and in view of the importance to otologists of a thorough knowledge of the subject, the following paper has been prepared.

ANATOMIC MATERIAL.

The illustrations, with the exception of numbers one and seven, are photographs of specimens carefully selected from several hundred serial sections made by the author while at the neurobiologic institute of the University of Berlin. The first picture is of a temporal bone from the writer's collection. The seventh illustration is a photograph of a specimen belonging to the University of Vienna.

The sections of the medulla are stained according to the Weigert-Pal method. The ear specimens are stained partly with hematoxylineosin, partly with Van Gieson's picric acid fuchsin.

DESCRIPTION OF SPECIMENS.

Of the following illustrations I-VII show the relations of the vestibular apparatus and the endings of the nervus vestibularis in the labyrinth. A, B, C and D show the vestibular

nuclei, the nuclei of the abducens and oculomotor nerves, and the central course of the nervus vestibularis.

Fig. I. Sagittal section of a normal adult temporal bone, showing the prominence of the horizontal semicircular canal on the median wall of the mastoid antrum (1). Just inferior to this is the facial canal (2). Anterior to the facial canal is the median wall of the tympanic cavity with its promontory (3), fenestra ovalis (4), entrance to the fenestra rotunda (5), etc. Anterior to the tympanum is the carotid canal (6). Inferiorly is the bony vault for the jugular bulb (7). The object of this picture is to give a clear idea of the relations of the outer wall of the vestibular apparatus to the tympanic cavity and mastoid antrum.

Fig. II. Frontal section through the tympanic cavity and labyrinth of a three months' embryo. Superiorly is seen the prominence of the horizontal semicircular canal (1). Below this is the facial nerve (2). Inferior to the facial is first the oval window with stapes (3), next the promontory (4), then the round window closed by the membrana tympani secondaria (5). Superiorly in the labyrinth is the ampulla of the horizontal canal (6). On its external wall is a crista acustica, below which may be seen the communication between the ampulla and utriculus. On the lateral wall of the utriculus (7) is its macula acustica. To the median side of the oval window is the cysterna perilymphatica of the vestibule (8).

Fig. III. Frontal section through the external auditory canal, tympanic cavity, mastoid antrum, labyrinth and internal auditory meatus of a normal adult temporal bone. On the median wall of the antrum is the prominence of the horizontal semicircular canal (1). Above and internal to this is the anterior vertical semicircular canal (2). Inferior to the horizontal canal is the facial nerve (3), the fenestra ovalis (4), the promontory (5), and the cellulæ tympanicæ (6). To the median side of the promontory is the beginning of the cochlea (7). Internal to the foot-plate of the stapes is the cysterna perilymphatica of the vestibule (8). Above this is the utriculus (9), which communicates superiorly with the ampullæ of the horizontal and anterior vertical canals. To the median side of the vestibule is seen the internal auditory meatus (10). This picture is given chiefly to demonstrate the position of, and intimate relation existing between the ampullæ of the horizontal and anterior vertical semicircular canals.

Fig. IV. Horizontal section through the middle ear and labyrinth of a child's temporal bone. The region shown is that of the round window. Just anterior to the membrana tympani secondaria (1) is the beginning of the cochlea (2). To the median side of the fenestra rotunda is the ampulla of the posterior vertical semicircular canal (3). On the anterolateral wall of the membranous ampulla is the crista acustica or crista ampullaris (4). This picture demonstrates the close relation existing between the ampulla of the posterior canal and the round window.

Fig. V. Transverse section through the ampullary end of a semicircular canal showing crista ampullaris (1). It is seen that the membranous ampulla almost fills the cavity of the osseous (2), whereas the membranous canal elsewhere only occupies about one-fifth of the osseous. The membranous ampulla is attached to the osseous by means of numerous bands of connective tissue (3), which serve for the passage of blood vessels as well as for the support of the ampulla. The crista acustica is seen to be composed of, first, a loose connective tissue basis, through which pass the fibers of the nervus utriculo-ampullaris. Resting upon this is a more compact layer of connective tissue, the membrana propria (4). Above the membrana propria is a layer of endothelial cells (5), the center ones of which carry the long hairs which form the cupola (6). These hairs are held together at their ends by means of a homogeneous semisolid substance (7). To the lateral side of the ampulla are seen fibers of the nervus utriculo-ampullaris on cross section (8). The membranous canal (9) is filled with endolymph, the surrounding space containing perilymph.

Fig. VI. Horizontal section through the oval window and vestibule of an adult temporal bone. Laterally is the foot-plate of the stapes (1). Posterior to this is the facial nerve (2). The large space in the vestibule to the median side of the stapes is the cysterna perilymphatica (3). Attached to the posterior and median walls of the vestibule is the utriculus (4). On the lateral wall of the utriculus is its macula acustica (5). Posteriorly are seen cross sections of the vestibular nerve fibers (6).

Fig. VII. Membranous labyrinth of the right side prepared from a normal temporal bone. Anteriorly is the cochlea (1). At

the beginning of its basal turn is the fenestra rotunda (2). Just above and anterior to the round window is the sacculus (3). Communicating with the sacculus superiorly and to its posterior side is the utriculus (4). Posteriorly are seen the three semicircular canals; above the anterior vertical (5), in the center the horizontal (6), below the posterior vertical (7). The ampullæ (8) of the anterior vertical and horizontal canals are seen together superiorly. Inferiorly, in the region of the round window, is the ampulla (9) of the posterior vertical canal. The purpose of this illustration is to show the exact position of all three semicircular canals, their relations to each other and to the remainder of the labyrinth.

Fig. A. Transverse section of the medulla through the upper end of the inferior olive (1), showing the beginning of the ramus cochlearis (2) of the nervus acusticus. The anterior cochlearis nucleus (nucleus accessorius acustici) (3) is seen anterior to the corpus restiforme (4) and is buried in the trunk of the nervus cochlearis. This nucleus takes up most of the fibers of the nervus cochlearis. Some of these fibers, however, combined with fibers springing from the anterior cochlearis nucleus curve laterally around the corpus restiforme as the lateral acustic root and find an interruption posterior to the corpus restiforme in the nucleus cochlearis dorsalis, the so-called tuberculum acusticum (5). The continuation of this system of the cochlearis is carried out by the striæ acusticæ (6), which run along the floor of the fourth ventricle toward the median line, crossing at different levels. Near the median line the fibers separate a little to take in the nucleus eminentiæ teretis (7). Just anterior to these striæ is the small cell triangular vestibular nucleus, the nucleus vestibularis parvicellularis (8). To the lateral side of this nucleus is seen in transverse section the spinal acusticus root, which may be divided into three parts; most median are the descending fibers of the vestibular (9), laterally the connection between the nuclei of the medulla and the cerebellum, the tractus nucleocerebellares (10), which touches the restiform body, and between the two the large cells of Deiter's nucleus, the nucleus vestibularis magnocellularis (11).

Fig. B. Transverse section through the medulla at a higher level than section A. The ramus vestibularis is here seen in its entirety (1). The chief mass of fibers is directed toward the

small cell triangular vestibular nucleus (2), while a second part curves toward the large cells of Deiter's nucleus (3). Some of the fibers of the vestibular together with fibers from Deiter's nucleus take the dorsal course of the restiform fibers (4); the first reach the small cell nucleus angularis (Bechter nucleus) (5), the second passing to the nucleus fastigii in the cerebellum. The nucleus angularis is situated median to the brachium conjunctivum. A bit of the facial nucleus is seen, the fibers of which surround the nucleus of the abducens (6), after which they form the ascending arm of the facial. This is situated just dorsal to the fasciculus longitudinalis posterior (7).

Fig. C. Transverse section through the beginning of the pons, showing the continuation of the acustic fibers. In the tegmental region is seen a bundle of fibers, which originate in the ventral cochlearis nucleus, anteriorly winding around the spinal trigeminus root and then curving in a bow toward the median line, where they cross. This bundle, which in animals with a shorter pons lies exposed on the surface, is the corpus trapezoides (1). In its lateral third is buried the superior olive (2). From the corpus trapezoides radial bundles extend into the olive anteriorly, while dorsally the so-called pedicle fibers (3) enter. These dorsal fibers are the continuations of the striæ acusticæ. In the corpus trapezoides small cell nests form the trapezoid nucleus. The superior olive lies in close relation to the facial (4) and abducens (5). The nucleus of the facial lies dorsolaterally, the trunk passing to the lateral side of the olive. The abducens passes through the tegmentum median to the olive. In this section are also seen remains of the large (6) and small (7) cell vestibular nuclei. The small cells just posterior to the cells of Deiter belong to the nucleus angularis. At (8) is seen the nucleus of the abducens.

Fig. D. Transverse section through the anterior portion of the cerebral peduncle, through the red nucleus of the tegmentum (1), and through the superior corpus quadrigemina (2). The picture is given chiefly to show the position of the oculomotor nucleus (3). This nucleus consists of several distinct groups of cells lying on the floor of the aqueduct (4) close to the middle line and nearly corresponding in position to the superior quadrigeminal body. It is just dorsal to the posterior

longitudinal fasciculus (5). Anteriorly are seen fibers of the oculomotor nerve (6).

DESCRIPTION OF CENTRAL COURSE OF THE VESTIBULAR NERVE AND OF THE DIFFERENT NUCLEI WHICH AID IN THE CAUSATION OF NYSTAGMUS.

The vestibular nerve fibers, after being interrupted in the vestibular ganglion in the internal auditory meatus, pass directly to the medulla oblongata, in which to the median side of the corpus restiforme (B4) they divide into an ascending and a descending branch, the latter forming the most median portion (A9) of the spinal acustic root which descends as far as the region of the hypoglossus. Some of these fibers end in the small cell vestibular nucleus (B2), their continuations, which may be followed down to the hypoglossus, being known as the descending vestibular nucleus, nucleus intercalatus Staderini. Direct continuations of the ramus vestibularis also reach Deiter's nucleus and the nucleus angularis. From Deiter's nucleus (C6) proceed fibers on the one hand to the nuclei of the eye muscle nerves (C8-D3), through the fasciculus longitudinalis posterior (B7-D5) (some of the fibers crossing, others remaining on the same side), and to the cerebellum; on the other hand, crossed and direct fibers pass downward to the motor cells of the anterior horns of the cord. If any of the fibers go direct to the cerebral cortex, or if all are first subjected to an interruption in the nuclei of the eye muscle nerves, is still an open question.

Concerning the exact course of the central tracts from the vestibular region to the cerebrum, it is known only that they pierce the substantia reticularis of the region just above the transverse fibers of the pons, pass to the thalamus, and from there, after an interruption, reach the cortex and are supposed to end in the posterior part of the parietal lobe.

PRACTICAL APPLICATION.

From the illustrations and description it is seen that the two vestibular apparatuses are brought into relation with Deiter's nucleus by means of certain of the vestibular nerve fibers. Further, that Deiter's nucleus is brought into relation

with the nuclei of the eye muscle nerves through the fasciculus longitudinalis posterior. As a result of these relations, the two vestibular apparatuses are enabled to exert a definite influence over the eye muscle nerves. Normally this influence is equal. Any disturbance in the equilibrium of these vestibular stimuli results in an oscillatory movement of the eyes, nystagmus. By means of the fibers passing from Deiter's nucleus to the cerebellum, disturbances of the latter may also give rise to nystagmus.* In the vestibular form of nystagmus the slow component alone is due to vestibular influence, the rapid component being the result of voluntary effort to bring the eyes back to the normal position.

In the diagram presented, the entire central mechanism of vestibular nystagmus may be studied. V. A. represents the vestibular apparatus of the left side. The vestibular nerve fibers are first interrupted at V. G., the vestibular ganglion in the internal auditory meatus. From here they pass directly to the medulla, some ending in the small cell vestibular nucleus V. N., others in Deiter's nucleus D, and still others in the nucleus angularis A. From Deiter's nucleus and the nucleus angularis pass fibers directly into the cerebellum C. From Deiter's nucleus fibers pass also to the fasciculus longitudinalis posterior F. L. P. The fibers of the fasciculus longitudinalis posterior are seen to communicate with, first, the abducens nucleus Ab. and superiorly with the oculomotor nucleus Oc., both of the right side. From these two nuclei of the right side the two nerve trunks are traced to the eyes. Although Deiter's nucleus of each side is in communication with the abducens and oculomotor nuclei of both sides, the crossed fibers are the more important. For this reason the latter alone are given in the diagram.

At G. A. is the cortical center for voluntary movement of the eyes to the left. This center, in gyrus angularis, gives rise to the rapid component of vestibular nystagmus.

The diagram illustrates how vestibular nystagmus may be caused to the left from, for instance, an increase in the normal stimulation from the left vestibular apparatus. The increase in the normal stimulation passes from V. A.-V. G. directly to

*The fibers passing from Deiter's nucleus to the cord explain the disturbance of equilibrium which accompanies marked nystagmus.

D. of the left side. From D. most of the stimulation passes through F. L. P. of the right side to the abducens and oculomotor nuclei, Ab. and Oc. From these two nuclei the stimulus finally reaches the eye muscles through the abducens and oculomotor nerves. The result is a slow movement of the eyes to the right. As soon as the eyes have reached extreme vision to the right from vestibular action, they are jerked back toward the left by voluntary action originating in the gyrus angularis of the right cortex. The center for voluntary vision in the right gyrus angularis acts first upon the cells of Monakow (M in the diagram) of the left side (center for vision to the left). From here the stimulation passes through a supranuclear tract to the two nuclei Ab. and Oc. of the left, and thus finally to the eyes. The action then of the gyrus angularis is to cause the rapid component of vestibular nystagmus.

EXPLANATION OF THE PERIPHERAL MECHANISM OF VESTIBULAR NYSTAGMUS.

Having explained the central mechanism of vestibular nystagmus, the peripheral remains to be considered. Each vestibular apparatus consists of three semicircular canals (VII-5, 6, 7) and a vestibule, the latter containing the utriculus (VII-4) and the sacculus (VII-3). Each semicircular canal possesses an indifferent and an ampullary end. In the ampullary ends of the membranous canals are situated the cristae acusticae (V-1). Resting upon each crista is a cupola (V-6) consisting of minute hairs held together by a homogeneous semisolid substance (V-7). The cristae acusticae represent the nerve endings of the nervus vestibularis in the semicircular canals. The macula acustica of the utriculus (VI-5) represents the nerve endings of the nervus vestibularis in that organ. Laterally, just to the median side of the inner wall of the mastoid antrum are the ampullæ of the horizontal and anterior vertical canals (VII-8). Internal to the region of the round window is the ampulla of the posterior vertical canal (IV-3 and VII-9). Midway between the two ends of the posterior canal is the crus simplex of the horizontal canal. Above this point and near the posterior surface of the pyramid is the crus communis of the two vertical canals.

The canals communicate with the utriculus by means of five openings.

As above stated, the two vestibular apparatuses normally exert a certain influence over the nuclei of the eye muscle nerves. Just what this influence is and just how it is exerted is not thoroughly understood. Whether the stimulus results from movements of the hairs composing the cupolas, or whether it is a constant force exerted by the vestibular apparatus as a whole and independent of any such movement is not known. I have also mentioned that a disturbance in the equilibrium of the influence exerted by the two sides results in vestibular nystagmus. For example, if one labyrinth is accidentally destroyed during a radical mastoid operation, the influence exerted by the vestibular apparatus of the injured side is removed so that the healthy side acts alone. Being accustomed to acting with the vestibular apparatus of the injured side, the healthy side over acts, as it were, the moment the other side ceases to functionate. The result is a sudden and marked vestibular nystagmus to the healthy side.

TURNING NYSTAGMUS.

Turning nystagmus may best be explained by first giving a short description of Ewald's experiment upon pigeons.

The right horizontal semicircular canal (VII-6) is exposed by dissection. A short distance posterior to the ampulla an opening is made in the osseous canal and the canal completely plugged. (See A in accompanying diagram.) Between this point and the ampulla a second opening is made in the bony canal. To this opening is attached a small pneumatic hammer controlled by a rubber bag and tube (B in diagram). By means of this hammer the membranous canal may be compressed or released by compressing the air in the bag or aspirating air from the tube into the bag. Now the canal being completely closed at A posteriorly, the endolymph can flow in but one direction upon compression and in but one direction upon aspiration. In other words, it must flow, upon compression, toward the ampulla (C) and utriculus (D); upon aspiration, from the utriculus and ampulla back to the canal. Upon compression (the right canal being used for the test) there occurs a slow horizontal movement of the head and

eyes to the left, which corresponds to a horizontal nystagmus to the right. Upon aspiration there occurs a slow movement of the eyes and head to the right corresponding to a horizontal nystagmus to the left. This experiment demonstrates the dependence of definitely directed eye and head movements upon the direction of the flow of endolymph in a definite semicircular canal. The same experiment may be made with the anterior and posterior vertical canals, the resulting movement in each case being in the same plane as the canal tested.

Under normal conditions, a movement of endolymph in the semicircular canals resulting in a reflex nystagmus occurs when an individual is turned in one direction a number of times. For example, if an individual with head erect is placed in a revolving chair and turned to the right, in the beginning the endolymph remains still while the canals turn to the right, this amounting to a flow of endolymph from the canal toward the ampulla and utriculus in the case of the right horizontal canal. Now, if the turning is continued even for a few seconds the endolymph accompanies the canal in its movement to the right. The movement from the canal to the utriculus in the beginning is, however, sufficient to cause, during the turning, a horizontal nystagmus with the rapid component to the right. The endolymph in the left canal is, in the beginning, flowing in the opposite direction, that is, from the utriculus toward the canal. This proves that the movement of the hairs of the crista ampullaris toward the utriculus caused by the flow of endolymph in that direction is the physiologically more active movement. If the turning is now suddenly stopped the endolymph continues its movement for a moment from the utriculus to the canal in the right canal, whereas the canal itself remains still. In the left canal at the same time the flow is from the canal toward the utriculus; this latter being the physiologically more active direction, the nystagmus is now to the left.*

These experiments prove beyond all doubt that turning nystagmus is the result of ampullary hair movements, the direction being dependent upon the flow of endolymph.

So-called compression nystagmus, seen in cases of fistula of the labyrinth wall, may be explained in the same way.

*By changing the position of the head all forms of vestibular nystagmus, including rotatory, vertical, horizontal, and combinations of the three, may be caused.

CALORIC NYSTAGMUS.

Caloric nystagmus may be explained in the following manner:

If cold water is injected into the right ear of an individual possessing an intact vestibular apparatus, there occurs, when the head is erect, a rotatory nystagmus to the left. If instead, water above the body temperature is used, there results a rotatory nystagmus to the right. If the right ear is syringed with cold water and the head is bent forward and downward 180° so that the crown points toward the floor, there occurs a rotatory nystagmus to the right side. Syringing with hot water, then, has the same effect as bending the head downward 180° after syringing with cold water. The explanation of this, according to Barany, is as follows: When an ear is syringed with cold water, the endolymph nearest the lateral wall of the vestibular apparatus sinks as a result of that portion of the labyrinth being reduced in temperature. This sinking of endolymph results in a definite endolymph flow, which in turn causes movements of the ampullary hairs and thus finally nystagmus. Hot water in causing the endolymph to rise results in a flow in the opposite direction, and in nystagmus in the opposite direction to that caused by cold water. Now syringing the right ear with cold water (head erect) results in a rotatory nystagmus to the left, because with head erect the summit of the anterior vertical canal forms the highest point in the labyrinth, while its ampulla is in close relation to the lateral wall. When the latter is syringed with cold water the endolymph in the anterior vertical canal will move from the summit toward the ampulla. The same endolymph movement may be caused by bending the head toward the left shoulder. This results in rotatory nystagmus to the left. In the same manner, cold water, when syringed in right ear (head erect), causes rotatory nystagmus to the left.*

If the right ear is syringed with cold water and the head bent upon the left shoulder there results a horizontal nystagmus to the right. If the head is inclined toward the right

*With the head bent forward and downward 180 degrees the summit of the anterior vertical canal becomes the lowest point in the labyrinth. In this position cold water results in a flow of endolymph from ampulla to summit and rotatory nystagmus to the side tested.

shoulder there results a horizontal nystagmus to the left. This is explained in the following manner: By bending the head toward the left shoulder we place the horizontal canals in a vertical position. The summit of the arch of the right horizontal canal now forms the highest point in the right labyrinth. The ampulla lies just median to the lateral wall. If this wall is now syringed with cold water, the endolymph moves from the summit toward the ampulla. This same movement is obtained by turning an individual, head erect, to the right. This, we know, results in horizontal nystagmus to the right. In the same manner horizontal nystagmus to the right results from syringing the right ear with cold water, the head being bent upon the left shoulder. With the head bent toward the right shoulder the ampulla of the right horizontal canal is higher than the arch, so that syringing with cold water in this position will result in nystagmus to the left.

GALVANIC NYSTAGMUS.

The explanation of galvanic nystagmus is as follows:

Application of the kathode to the right ear results in katelectrotonus of the affected nerves. This acts as an irritant, and in addition increases the conducting power of the nerves so that from the periphery the normal stimuli become strengthened. The stimuli, conducted from the right vestibular apparatus to the eye muscle nerves, being now greater than the normal stimuli from the left side, a nystagmus to the right results.

The anode, when applied to the right ear, results in the nerve condition called anelectrotonus, which decreases the conducting power of nerves, so that from the periphery fewer stimuli reach the nuclei of the eye muscle nerves. In this condition the stimuli conducted from the left vestibular apparatus will be greater than those from the right. The result is a nystagmus to the left side. Application of the anode to the left ear, of course, results in nystagmus to the right.

Whether the galvanic current acts upon the peripheral endings of the vestibular nerve, upon its trunk, or directly upon Deiter's nucleus in the medulla is not known. The probability is that either Deiter's nucleus or the vestibular nerve trunk is directly affected as the same reaction, above described, has been obtained in a case where the vestibular apparatus of the side tested had been previously removed by operation.

SUMMARY.

1. The vestibular apparatuses exert a certain influence over the eye muscles.

2. This influence or stimulation is conducted through the vestibular nerves to Deiter's nucleus in the medulla.

3. From Deiter's nucleus of each side the stimuli are carried through the fasciculus longitudinalis posterior to the abducens and oculomotor nuclei of both sides, the cross fibers conducting the greater stimulation. From the four nuclei of the eye muscle nerves the stimuli are conducted to the eyes.

4. Normally the influence exerted by the two vestibular apparatuses is the same.

5. Any disturbance in the equilibrium of the influence exerted by the two sides, whether it be an increased stimulation from the one side or a diminished stimulation from the other, results in nystagmus.

6. Turning, caloric, and compression nystagmus are all the result of definite ampullary hair movements caused by endolymph flow.

7. Vestibular nystagmus has two components, a slow and a rapid. The slow component results from vestibular action, the rapid is voluntary and originates in the gyrus angularis of the cerebral cortex.

Metropolitan Building.

FIGURE I.

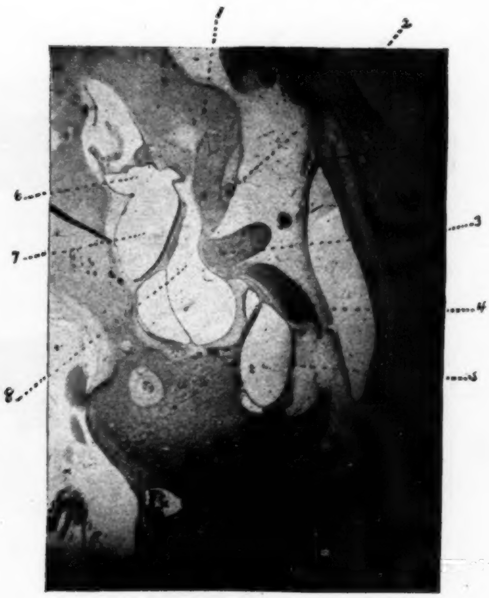


FIGURE 2.

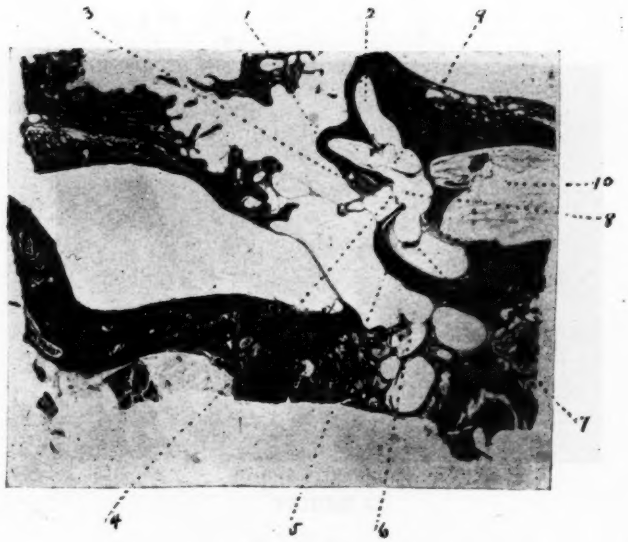


FIGURE 3.

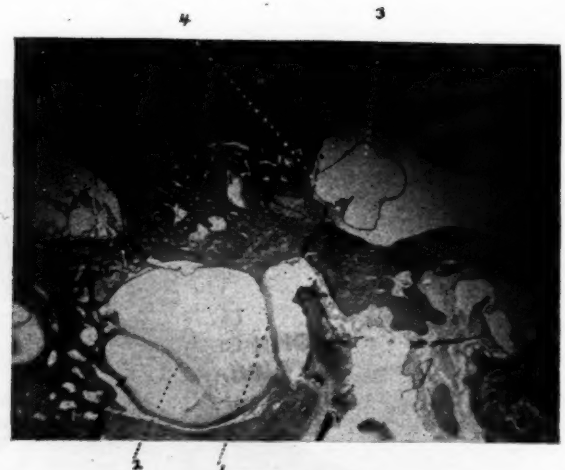
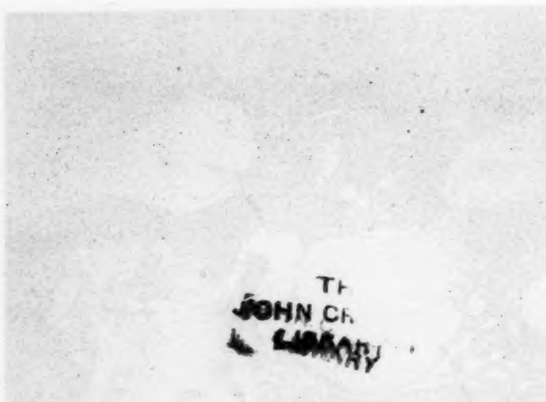


FIGURE 4.



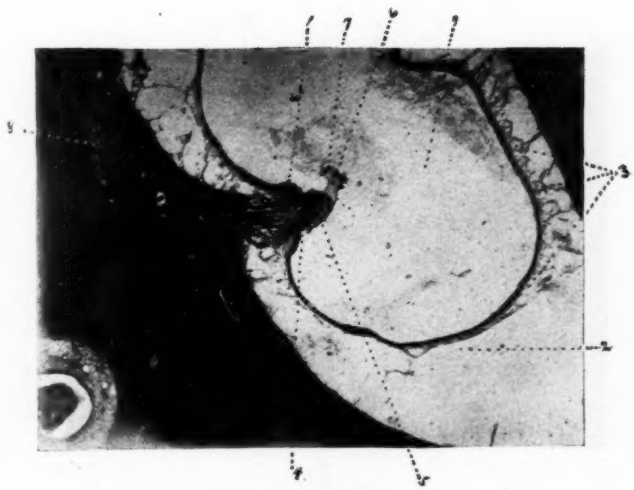


FIGURE 5.

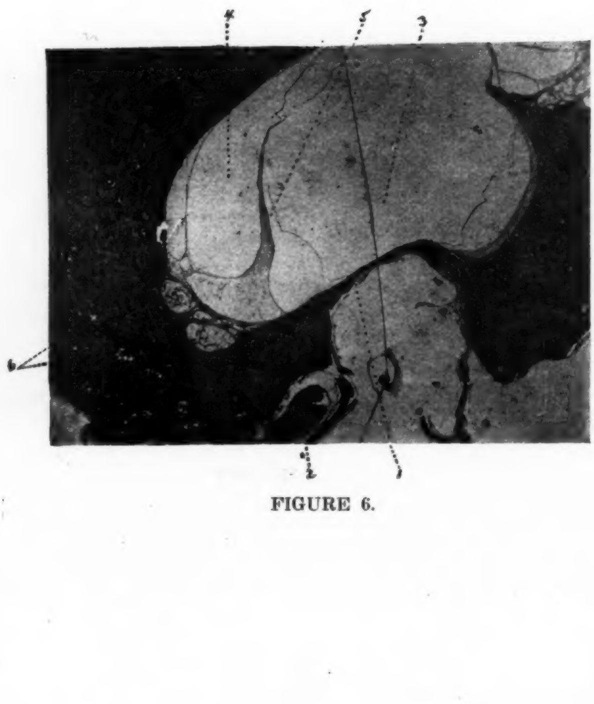


FIGURE 6.

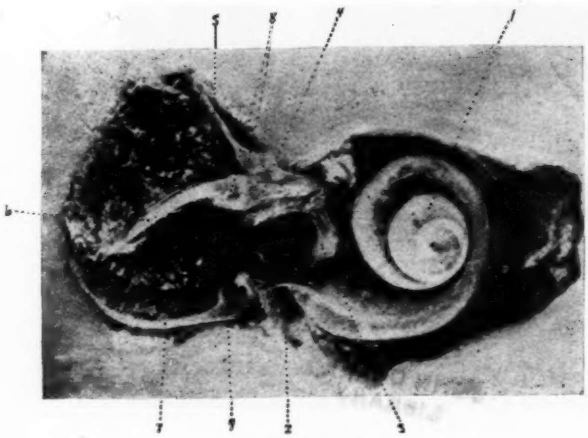


FIGURE 7.

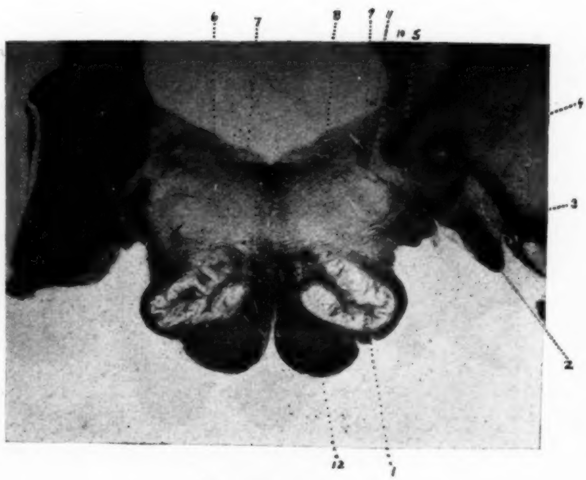


FIGURE A.

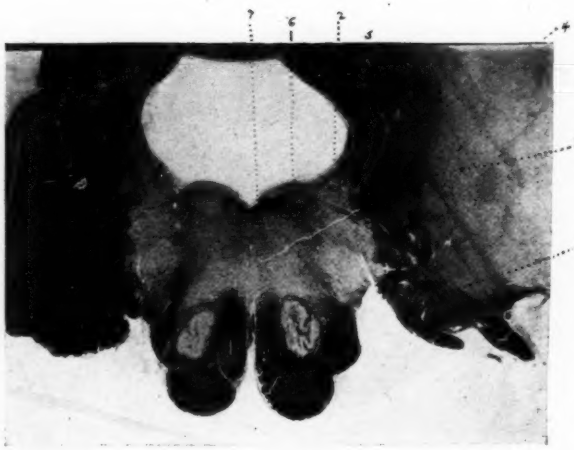


FIGURE B.

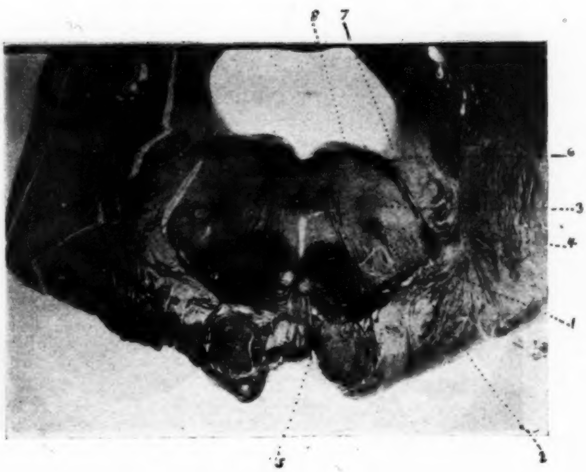


FIGURE C.

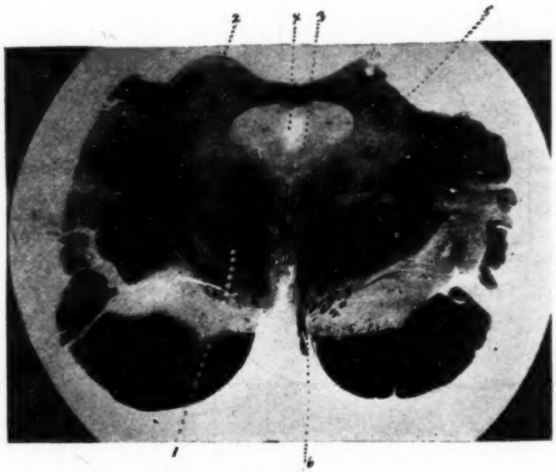


FIGURE D.

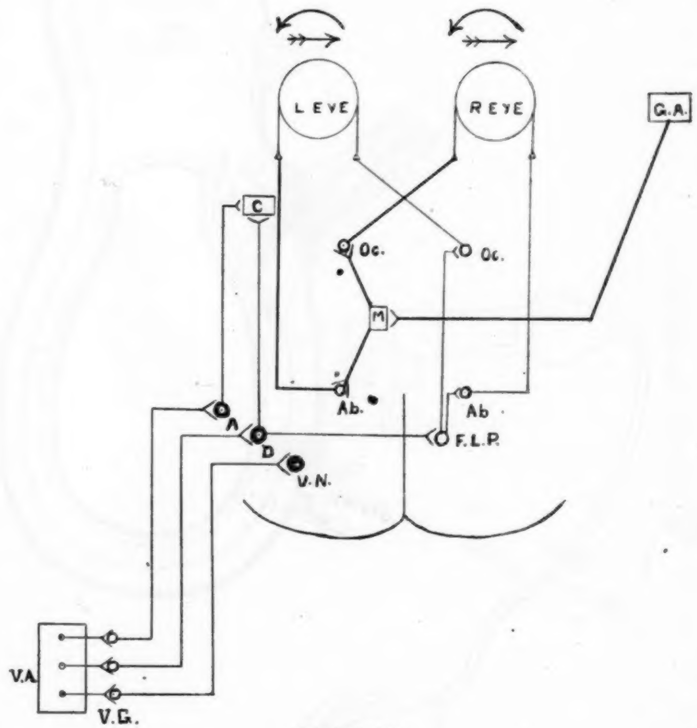
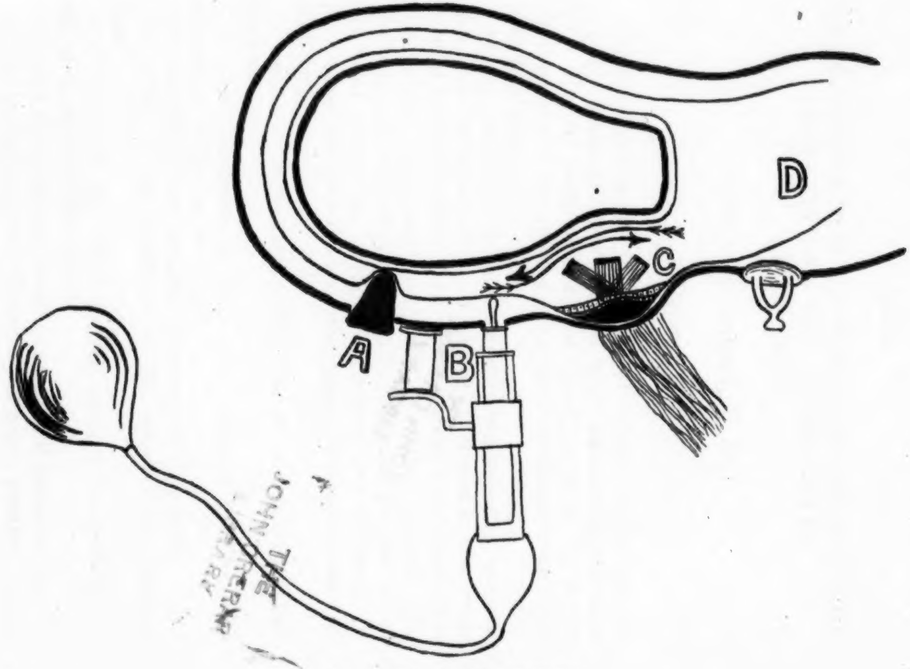


DIAGRAM.



EWALD'S EXPERIMENT.

LXII.

AN INVESTIGATION OF POSTOPERATIVE CONDITIONS FIVE TO TEN YEARS AFTER INTUBATION.

By Burt R. Shurly, M. D.,

Detroit.

An investigation into the results of surgical work, five, ten or fifteen years afterward, proves most fascinating and valuable. Medical literature does not afford, so far as the writer can determine, a record of postoperative conditions some years after intubation.

As the results of many operations are reported immediately after the work is done, it may be of interest to enumerate some of the observations after Dame Nature and Father Time have poured their soothing syrup over the surgical field. The object of this investigation is to determine the later after-effects of intubation, laryngeal diphtheria and antitoxin (if any) upon the structures of the upper respiratory tract in particular.

A series of interesting problems is at once presented for analysis.

1. Does intubation produce scar tissue or predispose to pathologic change in the larynx?
2. Are there late sequelae of laryngeal diphtheria?
3. What is the condition of the tonsillar or lymphoid ring?
4. What are the effects on the general susceptibility of the parts to other infections?
5. Are there any remote effects from the antitoxin used?
6. Is intubation ever followed by laryngeal paralysis of any variety, or by any impairment of phonation?

To answer these questions authoritatively would require a larger series of observations than these cases afford. It is possible, however, to obtain facts that will hold true in general.

Laryngeal diphtheria is more prevalent in our city among the ignorant, unsanitary foreigners, who live upon unpaved streets in thickly settled communities.

The difficulties of locating patients five to twelve years after operation is much greater than would be anticipated. Of a carefully recorded series of 437 intubations for laryngeal diphtheria, eighty per cent of whom were alive when the tube was removed, I have been able to locate and examine at the present writing thirty of the older cases.

Among superstitious and ignorant people the dread of a doctor's office is both apparent and ridiculous. Apprehension and mental panic can often be depicted in those individuals where the family physician, as such, is unknown; where the children are controlled by fear, and it is, therefore, difficult for them voluntarily to submit to examination.

The patients were reached (when possible) by earnest personal solicitation, by mail, by telephone or by messenger. In these observations a definite plan was followed. The method of examination included a reference to a detailed record, which was made at the time of operation, and to a series of ten simple questions, as follows:

1. From what illness has your child suffered since operation?
2. Has the child suffered from hoarseness at any time?
3. What throat trouble has been present?
4. Can the child breathe through the nose?
5. If not, what adenoid or other obstructive symptoms are present?
6. Have any diseases of childhood developed since operation?
7. Has any chest or ear trouble developed?
8. Does the child catch cold more easily since the attack of diphtheria?
9. Has the child had enlarged glands of the neck?
10. Has the child had shortness of breath, asthma or hay fever?

The usual examination of the nose, throat and larynx by means of the full office equipment was then made. In addition to this, any other family history of importance was sought for. The complete case report in detail is as follows:

Case 1. E. E., present age 18 years; intubated March 26,

1897; laryngeal diphtheria; six days since first appearance of exudate; doses of antitoxin, 2,500 units; tube removed 97 hours after; sequelae, none; other cases in family, none.

Result of examination twelve years later, March 5, 1909—Mild atrophic rhinitis right side; posterior discharge; hypertrophic tonsil left side; adherent pillars postpharyngeal wall; laryngitis with areas of atrophy; buried tonsil—right—with adherent anterior pillar; some thickening of lateral walls; postnasal discharge; some adenoid remnants; series of sore throat and tonsillitis every winter; no hoarseness nor cough; two sessile adenoid papilla on the right of the median line in the region of the lingual tonsil, touching the anterior subglottic wall, size of the head of a tack; no asthma; no bronchitis; all chest conditions negative; chronic nasopharyngitis; no trouble during the summer; slight hypertrophy of the left postcervical chain of lymphatics. Tonsil operation advised.

Case 2. E. W., present age 17 years 3 months; intubated March 2, 1896; laryngeal diphtheria; antitoxin 1,000 units; tube removed 60 hours after; sequelæ, none.

History since operation—Pneumonia two weeks in 1900; hoarseness occasionally in the fall; clears throat often; chokes before talking; no other throat trouble; no adenoid symptoms; does not catch cold easily; no asthma or shortness of breath; hypertrophy of thyroid; prominent sternocleidomastoid muscle.

Result of examination thirteen years later—Deflection upper third septum, first degree to the right. Spur cartilaginous anterior at the floor of the nose, left side. Granular pharyngitis; atrophic areas. Slight atrophic nasopharyngitis, in initial stage; throat never treated for any morbid condition; crescentic epiglottis; enlarged papillae; larynx slightly hyperemic; laryngoscopic examination difficult on account of neurotic condition. Shortening of the rim of the epiglottis, with deep clover-leaf cleft in the median line. Shortening of the aryepiglottic fold; no scar tissue visible.

Case 3. R. W. H., present age 14 years 3 months; intubated August 20, 1897; two days after first appearance of exudate; antitoxin 2,500 units; tube removed 96 hours after; no other case in family, but one across the street.

History since operation—Measles four years ago; chickenpox, mild; no hoarseness or throat trouble; does not catch cold more easily.

Result of examination twelve years after—Slight hypertrophic rhinitis inferior and middle; very slight spur floor right septum; very slight pharyngitis, with areas of highly atrophic tissue between; slight enlargement of the right tonsil; adhesion of the pillars, with negative symptoms; some adenoid—central; hypertrophic rhinitis continued to the posterior ends—mild; large lingual tonsil; epiglottis small—normal; larynx normal; slightest fullness of the mucous membranes just below the interarytenoid fold.

Case 4. M. K., present age 15 years 5 months; intubated July 8, 1897; four days since first appearance of exudate; antitoxin 1,500 units; tube removed 98 hours after; sequelæ, none; other cases in family, none; considerable cough after removal of tube.

History since operation—Pneumonia two years ago, sick one week; slight enlargement of the left postcervical chain; otherwise negative.

Result of examination twelve years later—Slight anemia; deflected bony and cartilaginous septum right side, with almost complete occlusion. Moderately high arched palate; teeth regular; enlarged tonsils; crypts exuding cheesy material; chronic lacunar tonsillitis; some adenoid. Postrhinoscopic examination shows roomy, posterior openings, slight bony deflection, but not obstructive. Slight dry cough through the winter, but not in the summer. Subglottic region; on the anterior wall to the right of the median line is a slight elevation of the mucous membrane the size of the head of a tack; mucus between the cords, which are normal in color. Operation recommended.

Case 5. L. K., present age, 10 years; intubated February, 1900; antitoxin 3,000 units; tube removed 92 hours after.

History since operation—Had scarlet fever lasting ten days; no hoarseness; snores some at night; does not "catch cold" more easily; no chest or ear trouble; no asthma or shortness of breath; two very slightly enlarged glands (left).

Result of examination nine years later—Left nasal passage normal; anterior right inferior turbinate slightly intumescent; very slight deflection of the upper third of the cartilaginous septum; nonobstructive. No enlarged adenoid; tonsils normal; lingual tonsil normal; slight thickening of the crest of the epiglottis, especially the median third. Laryngoscopic image normal.

Case 6. E. S., present age, 18 years 1 month; intubated December 22, 1896; antitoxin 1,000 units; tube removed (coughed out) 72 hours after; sequelæ none; other cases in family, none.

History since operation—Measles a few weeks after the operation; no hoarseness; earache occasionally; took cold once this winter, but not especially predisposed; no asthma, hay fever or shortness of breath.

Result of examination thirteen years later—Anterior nares normal; no spurs or deflections; follicular pharyngitis; irritable throat; no hypertrophy of cervical glands; slight acute nasopharyngitis, otherwise normal; epiglottis normal except injected with the coryza; laryngeal appearances are normal.

Case 7. J. A., age 19 years 2 months; intubated February 8, 1897; six days since first appearance of exudate; antitoxin 1500 units; tube coughed out nineteen hours after, reinserted two days later; sequelæ none; other cases in family, one brother.

History since operation—Has not seen a doctor since. Sore throat last week, but not before this time. None of the diseases of childhood.

Result of examination twelve years later—Acute coryza; intumescent turbinates; acute pharyngitis and nasopharyngitis; slight hyperemia of tonsils; follicles swollen and mucous membrane injected; small amount of mucus over postinferior turbinate; membrane to right of median line one-eighth of an inch below interarytenoid space; good view down to bifurcation; membrane normal; cords without scar; epiglottis normal.

Case 8. E. F., present age, 13 years 9 months; intubated August 9, 1909; three days since first appearance of exudate; antitoxin 1,500 units; tube removed sixty hours after.

History since operation—Measles at 6 years; cold and cough most of the time, with expectoration usually; slight laryngitis at present, "but not for a long time" before; sore throat and tonsils swollen twice since; croupy a good deal of the time. Never been able to breathe through nose since; snores at night; "catches cold" more easily; no asthma nor shortness of breath.

Result of examination nine years later—Nasal passages roomy; slight spur; cartilaginous and bony, left; small de-

flection at the floor, anteriorly; postnasal discharge every morning; hypertrophic lacunar tonsillitis, with very large inflamed crypts; inferior laryngeal wall atrophic; mucopurulent secretion; large adenoid in median line, with additional portion to the right of the median line the size of one-half the uvula; left posterior inferior turbinate hypertrophic and intumescent; cervical glands normal; croupy cough at present; lingual tonsil enlarged; upper laryngeal area above the vocal cords hyperemic and slightly swollen; film of mucus between the cords; small layer of mucus on the anterior laryngeal wall one-quarter of an inch below the vocal cords; roughness of interarytenoid fold. Operation recommended.

Case 9. E. Q., present age, 11 years 10 months; intubated October 4, 1899; five days after first appearance of exudate; antitoxin 4,000 units; other cases in family, none.

History since operation—Bronchitis and hoarseness every winter until two years ago; cannot breathe through nose well and cannot blow nose well; measles, mumps, and chicken-pox since; trouble with right ear two years later; "catches cold" more easily since operation; no enlarged glands; for eight years had "asthma" at night (probably adenoids). Operation advised.

Result of examination nine years later—No enlarged cervical glands; thick crust over turbinate, left; roomy nasal passages; slight cartilaginous spur, anterior; moderately high arched palate; no crowded teeth; throat red; tonsils not enlarged, ragged in appearance; slight papillary eminence at the junction of the uvula and anterior pillar, left side. Moderately enlarged adenoid glands, central mass; tonsils adherent to the pillars; appearance of extensive old inflammatory condition; clears throat a great deal; epiglottis rather thick, not abnormal; laryngeal examination difficult. Adenectomy advised.

Case 10. R. E., present age, 17 years 7 months; intubated November 5, 1899; first appearance of exudate (tonsils) two weeks, larynx three days; antitoxin 2,500 units; other cases in family, one; sequelæ, none.

History since operation—Had scarlet fever; acute laryngitis four days last winter; one attack of bronchitis; does not "catch cold" more easily; lower jaw prominent.

Result of examination ten years later—Symmetrical devia-

tion of septum, left; right nostril roomy and normal; hard palate somewhat high arched; uvula smaller than normal and triangular in shape; chronic lacunar tonsillitis; crypts large, without cheesy deposits; posterior pillars thickened, extend into the uvula; left tonsil hypertrophied slightly; right tonsil adherent and not protruding beyond the pillars; nasopharynx, very slight amount of adenoid tissue. Rhinoscopic picture normal; epiglottis slightly more hyperemic than normal, slightly roughened, with fine papillæ. Impossible to get a view further down than the top of the arytenoids, which seemed normal. Very slight enlargement of the anterior cervical glands.

Case 11. A. L., present age, 15 years; intubated November 7, 1899; four days since first appearance of exudate; antitoxin 2,000 units; tube removed 108 hours after; sequelæ none; other cases in family, none.

History since operation—Measles about a year after; no hoarseness; clears throat some; does not cach cold more easily; has attacks of "nose bleeding"; no enlarged glands, excepting with a "cold."

Result of examination ten years later—Slight bony cartilaginous ridge, left; good breathing space anteriorly; right anterior view normal; chronic hypertrophic lacunar tonsillitis; central adenoid with mucopurulent secretion extending over the vomer; otherwise rhinoscopic picture normal, very slight thickening of mucous membrane just to the left of the median line on the lower border of the interarytenoid fold. Vocal cords normal. A view down to the bifurcation. Tracheal wall rather dry; no evidences of scar tissue in subglottic region. Adenectomy advisable.

Case 12. E. K., present age, 14 years; intubated November 2, 1900; five days after first appearance of exudate; antitoxin 2500 units; tube removed 96 hours after; sequelæ, none; no other case in the family.

History since operation—Sore throat every winter since; no doctor since; slight huskiness of voice; no diseases of childhood since; does not "catch cold" more easily; no enlarged glands, no asthma nor shortness of breath.

Result of examination nine years later—Slight cartilaginous spur, right; otherwise, anterior view of both nostrils normal; chronic hypertrophic lacunar tonsillitis; slightly hypertrophic adenoid covered with mucopurulent secretion; slightly en-

larged lingual tonsil; laryngoscopic image normal, except for slight thickening of the vocal cords; no hyperemia; no scars apparent; uvula normal; laryngeal wall bathed with mucus.

Case 13. L. K., present age, 12 years 11 months; intubated April, 1900; antitoxin 2500 units; sequelæ, none; tube removed 96 hours after.

History since operation—No diseases of childhood; voice husky at times during winter; hard breathing at night (winter), snoring some; prominent teeth, upper jaw crowded with teeth; catches cold more easily since; no enlarged glands; no asthma nor shortness of breath; one year later, another child in the family died of nasal diphtheria.

Result of examination nine years later—Teeth crowded; high arched palate; deflection of septum, cartilaginous; breathing room—fair left side; anterior nasal passages (right) normal anteriorly; large central adenoid bathed in secretion; hypertrophic chronic lacunar tonsillitis; mouth breather. Distance between tonsils about three-eighths of an inch; adherent at pillars; glands of posterior cervical chain, left, slightly enlarged; lingual tonsil large; upper border of epiglottis median line curled over and thickened; hyperemic condition of the larynx; thickening of the interarytenoid fold; vocal cords normal; no scar tissue apparent. Operation advised.

Case 14. E. K., present age, 11 years 10 months; intubated November 11, 1898; thirty-six hours after first appearance of exudate; antitoxin 3,000 units; no other cases in family.

History since operation—Had whooping cough the summer after operation; German measles at six years of age; hoarseness continued for a year after the operation; breathes through nose; conjunctivitis after antitoxin; "inflammation of the lungs" twice—soon after; "sickly for a year." Discharge from ear three months before operation, none since; does not "catch cold" more easily since; no enlarged glands; no asthma nor shortness of breath.

Result of examination ten years later, March 27, 1909—Anterior nasal view normal, excepting slight thickening of cartilaginous septum—right side; slight fissure on the floor of nose at the juncture of the skin and mucous membrane, from which there has been a series of expistaxes; pharyngoscopic view normal; postrhinoscopic view shows slight chronic nasopharyngitis with the posterior wall bathed with mucopus; adenoid

tissue very slightly enlarged; very slight enlargement of the postcervical chain of glands more on the right than the left side; arytenoid cartilage smaller than normal; larynx smaller than normal; child developing; clears throat before speaking; voice breaks on the first word frequently; vocal cords smaller than normal; larynx seemed rather dry; no scars visible; mucus between the vocal cords; subglottic region bathed with mucus; interarytenoid fold normal (smooth).

Case 15. E. G., present age 12 years; intubated November 22, 1898.

History since operation—Stuttered ever since operation; tonsillitis every winter; no hoarseness; breathes through nose; earache for four days, three weeks ago; had three "colds" this winter; stops stammering when he takes a short breath and then speaks. Makes a hissing sound when stammering.

Result of examination nine years later—Slight enlargement of cervical glands; small cartilaginous spur anterior (left); slight deflection of upper third of cartilaginous bony septum (right). Palate arched more than normal; one large central pharyngeal follicle; "buried tonsils" with pathologic crypts; mucus in the nasopharynx; adherent tonsils to anterior and posterior pillars; patient has collar tic; central adenoid extending down over the posterior wall; posterior nares normal; very large lingual tonsil, filling the region between the tongue and epiglottis; no cough; anterior tracheal wall bathed with mucus, no scars visible; no proliferations; larynx slightly hyperemic; film of mucus between the vocal cords in the region of the anterior commissure; otherwise normal; atrophic areas on the posterior pharyngeal wall. Operation refused.

Case 16. W. P., present age 14 years; intubated March 19, 1898; three days after first appearance of exudate; antitoxin 2,000 units; tube removed 124 hours after; sequelae none; a fatal case in the house (downstairs) a year before.

History since operation—Had hoarseness two months after tube was taken out, none since; breathes through nose; none of the diseases of childhood; discharge from ear twice, all right now, hearing good; does not "catch cold" more easily; no enlarged glands; no asthma, nor shortness of breath.

Result of examination eleven years after—Anterior nasal region normal; slight fullness of the cartilaginous septum; some dryness of the nasal mucous membrane; very large ton-

sils; large central adenoid that extends down the posterior wall of the nasopharynx; not many "colds;" clears throat a good deal; breathes through nose; no deflected septum; no mouth-breathing; examination difficult on account of tonsils coming together, much gagging; larynx shows no scar tissue; hyperemia of the larynx; lingual tonsil very much enlarged; posterior wall of the epiglottis bathed with mucus. Operation advised.

Case 17. F. S., present age 15½ years; intubated February 21, 1900.

History since operation—None of the diseases of childhood; no hoarseness; has had shortness of breath; "colds" occasionally—recovering quickly; no chest or ear trouble.

Result of examination nine years later—Dyspnea, not now as much as three years ago; remnant of adenoid; some coryza; hyperemia of inferior turbinates and moderate intumescence; small amount of mucopus in nasopharynx; pharyngeal wall shiny and without follicles; atrophic in appearace; larynx normal but hyperemic; no scars; vocal cords normal; trachea is visible for an inch.

Case 18. G. P., present age 12 years 2 months; intubated October 2, 1909; thirty-six hours after first appearance of exudate; antitoxin 2,500 units; tube removed 108 hours after.

History since operation—"Colds" and sore throat; curvature of the spine; tonsillitis this winter; snores at night, but breathes all right; no enlarged glands; no asthma, hay fever, nor shortness of breath.

Result of examination ten years later—Anterior nares normal; enlarged adenoid; chronic lacunar tonsillitis; larynx hyperemic; no scars; mother died seven years ago during parturition; father died last June of carcinoma of the stomach. Operation advised.

Case 19. D. G., present age 14 years; intubated December 2, 1896; two days after first appearance of exudate; antitoxin 1,500 units; tube removed 96 hours after; sequelae none; no other cases in the family.

History since operation—Had measles some years ago; no hoarseness; no throat trouble; no ear or ehest trouble; no enlarged glands; no asthma, hay fever, nor shortness of breath.

Result of examination twelve years later—Very narrow nasal passage—left with some thickening and deflection of the septum at the base; right nasal passage wider than normal; papillomatous eminence at the junction of the anterior fold of the pillar and uvular fold on either side and symmetrically; tongue stubborn; small adenoid bathed with mucopus; slightly enlarged lingual tonsil, cauliflower formation made up of a large number of little papillomatous excrescences and touching the epiglottis at a number of points; epiglottis small; larynx slightly hyperemic; laryngeal image normal.

Case 20. G. H., present age 14 years 11 months; intubated October 22, 1899; two days after first appearance of exudate; antitoxin 1,500 units; tube removed 96 hours after; no other cases in family.

History since operation—Had measles two years after; mumps every winter; hoarseness every winter, sometimes expectorates blood; sore throat, tonsils swelling; tonsillitis every winter; "catches cold" more easily; had four "hard colds" this winter; has enlarged glands, which the patient calls mumps; no shortness of breath, asthma or hay fever.

Result of examination nine years later—Nose, anterior normal; slight hypertrophy of follicles of pharynx; hypertrophy (moderate) of tonsils, especially right; slightly enlarged adenoid with rugae; larynx normal; arytenoids small, larynx developing; child just deevloped. Operation advised.

Case 21. H. S., present age 11 years 2 months; intubated Januaury, 1901; seven days after first appearance of exudate; antitoxin; tube removed 116 hours after; no other cases in family.

History since operation—Had chickenpox, no doctor since; hoarse for two weeks, no other throat trouble; breathes through nose; "catches cold" more easily; has cough with any cold; no enlarged glands; no asthma; no shortness of breath nor hay fever.

Result of examination eight years later—Slight cartilaginous knob (anterior) at the floor of nose, otherwise normal, left; right side anteriorly normal, slight enlargement of lymphatic postcervical chain (left and right); teeth widely separated and even; small uvula; tonsils normal; slightly anemic; mild follicular pharyngitis; nasopharynx normal; laryngeal image normal, excepting hyperemic through crying; "slight cold"

for a few days lately; pharynx hyperemic; tonsils buried and normal.

Case 22. C. V., present age 16 years; intubated October, 1897; antitoxin.

History since operation—Had measles, mumps, chickenpox and influenza; sore throat and la grippe every winter, treated at first with salt pork, if not better, gets doctor, usually once during winter; cough with "colds" usually, no discharge from ears; no asthma; no hay fever nor shortness of breath.

Result of examination twelve years later—Slight cartilaginous spur (left); right nasal passage normal, excepting mucopurulent discharge from posterior entrance. Chronic lacunar tonsillitis, buried and adherent tonsils, giving the appearance of much old inflammation; central adenoid is shrinking; posterior hypertrophies of the septum; posterior nares normal; slight thickening at the interarytenoid fold; slight scar on the anterior wall of larynx; vocal cords very dry, film of mucus between the vocal cords; adenoid remnants give appearance of hypertrophy in earlier life; chronic lacunar tonsillitis, with mucopurulent discharge from the nasopharynx; granular pharyngitis; little areas of atrophy. Operation advisable.

Case 23. G. J., present age 9 years; intubated December 14, 1904; seven days after first appearance of exudate; antitoxin; tube removed 48 hours later; replaced and removed the fifth day. No other case in the family.

History since operation—None of the other diseases of childhood; had no doctor since; continuous hoarseness, sometimes quite marked; "catches cold" more easily; no asthma, nor shortness of breath nor hay fever.

Result of examinatioin five years later—Eczema left nostril with mucopurulent discharge; right turbinate intumescent; "cold all winter." Tonsils and larynx examined by Dr. E. L. Shurly and myself; normal to all appearances. Huskiness due to muscular or nervous insufficiency. Nasopharynx, remnant of adenoid; three patali of adenoid on left anterior surface of nasopharyngeal anterior wall, a fingernail breadth above pillars; tonsils buried; no lingual hypertrophy.

Case 24. R. H., present age 12 years, 5 months; intubated December 31, 1902; five days after first appearance of exudate; antitoxin 2,000 units; no other cases in the family.

History since operation—Had stiff neck or "rheumatism"

for one week; no hoarseness; cannot breathe throuugh nose very well; high arched palate; none of the other diseases of childhood; one very small gland—right side; no asthma, nor hay fever nor shortness of breath.

Result of examination six years later—Slight deflection of nasal septum—right; chronic follicular pharyngitis; moderate enlargement of central adenoid—not sufficient for operation; slight amount of hypertrophy of lingual tonsil; epiglottis narrow, long and thin; larynx normal; patient of slender build, but "wiry."

Case 25. E. M., present age 11 years; intubated May 31, 1903.

History since operation—Has not had any illness or trouble of consequence since; some hoarseness for a month after; breathes through nose all right; no other diseases of childhood; does not "catch cold" more easily; two or three small enlarged cervical glands; no asthma, hay fever, nor shortness of breath.

Result of examination six years later—Slight deflection of nasal septum (left); nasal passage roomy, though; slight adenoid enlargement; faucial tonsils quite large and irregular; pharynx and upper larynx rather red; epiglottis quite pointed; arytenoids on uneven plane; vocal cords all right—but wet; trachea normal; no scar, no flattening of larynx.

Case 26. E. W., present age 23 years; intubated November 14, 1907; antitoxin 3,500 units; tube removed 78 hours after; sequelae, paralysis; no other cases in the family.

History since operation—Had mumps two years ago; one attack of hoarseness three years ago; breathes through nose all right; no other diseases of childhood; slightly enlarged cervical glands; tonsillitis every winter until having diphtheria, none since.

Result of examination twelve years after—Cartilaginous spur left; bleeding point on the anterior end inferior turbinate; right anterior turbinate swollen; high arched palate; chronic lacunar tonsillitis; cheesy deposit in the upper crypts; anemic pharyngeal wall and somewhat atrophic; slightly enlarged adenoid tissue of right faucial tonsil, none of the left; all nasopharyngeal paralysis complication past; diphtheritic cast of trachea removed before operation; very slight enlargement of postcervical glands; did have enlarged glands of anterior

right side—lower set—but these have almost faded away. Slight adenoid, shrinking; thickening of the septum posteriorly; absolutely no throat symptoms except clearing the throat occasionally; lingual blood vessels enlarged; epiglottis smaller than average; vocal cords slightly dry; slight thickening of the opposite parts of the vocal cords at the posterior third; trachea bathed in mucus; slight atrophic areas.

Case 27. C. M., present age 16 years, 9 months; intubated July 11, 1897. First appearance of exudate on tonsils, two weeks after, and larynx two days after; antitoxin 1,000 units; tube removed 96 hours after; no other cases in the family; sequelae, bronchopneumonia.

History since operation—Had not had any illness since; no other diseases of childhood; no hoarseness; no asthma nor hay fever.

Result of examination eleven years later—Slight extra dryness of mucous membrane with crust formation; slight atrophic rhinitis with crusts; marked atrophic pharyngitis; tonsils slightly enlarged; clears throat often; pharynx bathed in mucus; some slight enlargement of the postcervical chain (left); epiglottis very erect and small; roomy spaces in lingual tonsillar region; vocal cords slightly dry; tracheal rings very prominent; larynx otherwise normal; the opening bounded by the arytenoids slightly smaller than average.

Case 28. W. G., present age 15 years, 7 months; intubated January 18, 1897; nine days after first appearance of exudate (tonsils); croupous two days; antitoxin 2,000 units; tube removed 96 hours after; one other case in family, and one next door.

History since operation—Had scarlet fever at eight years of age; mumps shortly after that; rheumatism last year, very lame now, uses a cane to walk; tendons of right foot contracted; mouth breather part of time; tonsillitis just before rheumatism, lasting a month; no ear trouble since diphtheria, when purulent otitis med. developed; does not "catch cold" more easily; three moderately enlarged postcervical glands (left).

Result of examination twelve years later—Anemic; had rhêumatism; lately, again; septum straight; middle turbinate enlarged; anemic appearance of mucous membrane; right side deflection of nasal septum, in upper third; slight cartilaginous

spur anteriorly, lower turbinate and along floor; tonsils buried; faucial pillars markedly adherent anteriorly and posteriorly, atrophic pharyngitis; adenoid glands bathed with mucopus; very small choanae; large erect epiglottis; arytenoids small; tracheal wall atrophic; large larynx; vocal cords flabby; upper part of the larynx normal; vocal cords injected and appear as if epithelium were changed, pearly white color is lost; grayish, red and streaked, instead they are large, flat and flabby.

Case 29. M. R., present age 13 years, 8 months; intubated May 31, 1897; thirty-six hours after first appearance of exudate; antitoxin 2,000 units; no other case in the family.

History since operation—Had measles eight years ago; whooping cough seven years ago; has chronic conjunctivitis; no hoarseness; "sore throat often;" snores, is restless; dry cough most of the time; catches cold more easily; two moderately enlarged cervical glands (left); no asthma, nor shortness of breath, except with so-called "catarrh;" operation recommended.

Result of examination twelve years later—Anterior nasal passages on the left side roomy; posteriorly there is pus on the middle turbinate; the inferior turbinate shows marked intumesence plugging the right passage, large amount of thin mucopurulent secretion. Hypertrophy of both tonsils with marked adhesion to the anterior and posterioir pillars. Two calcareous flat patches not rising above the surface, on both vocal cords, beginning about one-sixteenth of an inch from the anterior commissure. Arytenoids slightly swollen; no scars visible; the tonsil concretions removed with the laryngoscopic mirror during examination. Operation advised.

Case 30. M. McK., present age 16 years, 2 months; intubated January 27, 1897; three days after first appearance of exudate; antitoxin 1,500 units; tube removed 124 hours after; no sequelae.

History since operation—Had measles at six years of age; one cold each winter; dry cough since last winter; breathes through nose all right; does not catch cold more easily; no asthma, shortness of breath nor hay fever.

Result of examination twelve years later—Slightly intumescent right inferior turbinate; good nasal breathing; slight cartilaginous spur (right side), nonobstructive; crowded teeth;

tonsils not projecting beyond posterior pillar; slight follicular enlargement of posterior pharyngeal wall; adherent tonsils throughout entire posterior border; anterior free; right tonsil somewhat smaller than the left. No history of tonsillitis or other inflammatory conditions since. Posterior choanae small, normal passage; slight mucous discharge, nonpathologic; no adenoid hypertrophy. Slight thickening of lingual tonsil. Hyperemic arytenoids. No scar on the cords nor interarytenoid folds; trachea normal.

SUMMARY OF EXAMINATION.

Of the thirty cases examined all had clinical laryngeal diphtheria.

The age varied at operation from seventeen months, the youngest, to eleven years, the oldest.

The smallest dose of antitoxin given was one thousand units; the largest four thousand units.

The time during which the tube was worn consecutively was from forty-eight hours to one hundred and twenty-four hours.

No instance of retained tube occurred in any of these cases. Four cases required reintubation.

In one case intubation had been attempted by two other operators during some hours, without success.

Other cases of diphtheria appeared in the same family or in the neighborhood, from which the contagion could be traced in five of these cases.

The subsequent statements show the extent of susceptibility of infectious or contagious diseases in these cases, as follows: Measles, ten cases; chickenpox, four cases; mumps, four cases; whooping cough, two cases; scarlet fever, three cases.

Partial or complete aphonia remained from one day to seven years after the removal of the tube.

"Throat disease" was claimed in ten cases.

Four cases were partial, periodic or complete mouth-breathers.

Other adenoid symptoms were present in six cases.

Lung or heart disease was noted in six cases.

Affections of the ears were acknowledged by four.

A greater susceptibility to coryza was observed in seven cases.

Dyspnea, asthma or hay fever in two cases (from adenoids).

The examination was made five years after intubation in one case, and from eight to twelve years later in the other cases.

Nasal conditions requiring operation—Deflected septum, four; intumescent and hypertrophied turbinates, two.

Nasopharyngeal conditions requiring operation—Adenoids, six cases.

Pharyngeal conditions requiring operation—Eight cases (tonsils).

Laryngeal conditions requiring operation—None.

Enlarged cervical glands were found in nine cases.

Thickening of the interarytenoid fold was observed in four cases.

CONCLUSIONS.

Every case in this series was intubated for laryngeal diphtheria.

1. Intubation in laryngeal diphtheria is required more frequently where marked tonsillar hypertrophy exists.
2. Pathologic adenoid and tonsils are prominent predisposing factors in diphtheritic infections of the larynx.
3. No deleterious effects of antitoxin were noted.
4. Laryngeal paralysis is extremely rare after intubation.
5. Little attention is often given by the physician or patient to nasal obstruction until serious damage results to the general health.
6. Numerous pathologic conditions of the upper respiratory tract may exist without symptoms or annoyance.
7. Scar tissue was observed in two cases. The cicatrix was insignificant and apparently produced no modification in function.
8. No case of laryngeal paralysis was found, although one with motor insufficiency was observed.
9. The pathologic effects of diphtheria on the tonsillar ring are numerous and aggravated.
10. Children developing laryngeal diphtheria show a marked tendency to other infections in childhood.
11. So-called chronic catarrhal inflammation of the upper respiratory tract is usual after severe diphtheria.

LXIII.

A CASE OF PURULENT PACHYMENINGITIS WITH EXTRADURAL ABSCESS, SUBDURAL ABSCESS, AND SEPTIC THROMBOSIS OF THE LATERAL SINUS, COMPLICATING CHRONIC SUPPURATIVE MIDDLE EAR DISEASE.

By James J. Carroll, A. M., M. D.

Baltimore.

Of recent years the publication of intracranial disease of otitic origin has been so frequent, it is with feelings of an apologist that the writer adds another to the rather long list of such cases in medical literature. However, as subdural suppuration is one of the least common results of otitis media, it may not be without interest to refer briefly to this rare complication and to cite a case in point which came under observation three years ago, and ended in complete recovery.

Suppuration, extending from the temporal bone to the subdural space, encounters a wonderfully good barrier to disease in the dura. How long this membrane may hold out against purulent inflammation it is impossible to say. But the evidence furnished by a number of cases of extradural abscess, met with in mastoid disease, would go to show that a pachymeningitis externa may last quite a little while. The pathologic process becomes more active, however, when the dura perforates and the suppuration passes to the inner side. If unchecked the pus will quickly invade the meshes of the pia or the substance of the brain. Occasionally the suppuration becomes circumscribed and the pus confined by adhesions between dura and arachnoid, giving rise to a subdural abscess. It is hardly conceivable, however, that such a condition could last long before the pus would attack the pia mater. Consequently a localized subdural suppuration, unaccompanied by either cerebral abscess or general leptomeningitis, must be looked upon as rare.

The first cases of subdural abscess seems to have been reported by Ceci and Onetti[1] in 1886. An abstract of this case was given by von Bergmann[2] in 1899, in the third edition of his book on the surgical treatment of diseases of the brain. Four cases were described by Macewen[3] in 1893. Subsequent ones have been published by Jansen,[4] Delstanche,[5] Milbury,[6] Leiszynski,[7] Lucae,[8] Meier,[9] Suckstorff and Henrici,[10] Manasse,[11] Hald,[12] and others. In some instances the condition has been described as a localized purulent meningitis. In the third edition of his book Körner[13] makes reference to sixteen cases. Heine,[14] in the second edition of his book on operations on the ear, cites three cases, all having been previously published, two in the Lucae Festschrift, 1905, and one in the Verhandlungen der Otologischer Gesellchaft, 1903.

The following is the writer's case, which was brought before the Ophthalmological and Otological section of the Baltimore City Medical Society, January, 1908:

F. C., female, 18 years old, had a left otorrhea since an attack of scarlet fever when three years of age. During the 15 years of her otorrhea she had several so-called "gathered ears." On April 24, 1907, patient was taken with pain in the left ear and headache; on the following day, nausea and vomiting. On the third day she had a chill at 4 a. m. and another at 9 a. m., each followed by profuse sweating. Dr. Geo. Hartman, in whose practice the case occurred, asked me to see her on the fifth day, April 29. Her general appearance then was that of a very sick person, with marked anemia, clammy perspiration over the forehead, some emaciation, drowsiness, coated tongue, temperature 101, rapid pulse. Patient was suffering with severe headache, which was increased by moving the head. In the left external meatus there was a small amount of foul-smelling pus. Posterosuperior wall was sunken, and obstructed very much the view of the drum. There was no redness or swelling over the mastoid, but considerable tenderness on pressure. Pain was caused by pressing upon the neck just below the tip of the mastoid process. There was slight enlargement of the glands along the sternocleidomastoid. Hearing, which had been impaired in the left ear for a long time, had become much worse during present illness. Diagnosis was an acute exacerbation of a chronic

mastoiditis with involvement of the lateral sinus. Immediate operation was advised. Patient entered St. Joseph's Hospital about 7:30 a. m., April 30th. Temperature 103 3-5, leucocytes 14,500. Urine free from albumin and sugar. Operation 9 a. m. same day under ether. Pathologic conditions presenting themselves were about as follows: Very slight subcutaneous infiltration; little free pus in fossa mastoidea; periosteum intact except over a small fistula in the cortex just behind the spina sprameatum; cortex very hard and thick, in places 7 to 8 mm. in thickness. Part of the inner plate of cortex was necrotic. There was no external wall to the antrum, which was filled with pus, necrotic granulations and cholesteatoma. Entire tympanum, including attic, filled with similar material. Roof of tympanum as well as antrum was pretty high, the bone fairly soft, but no fistula visible. Bone of the sigmoid sulcus seemed quite normal. Nowhere was dura or sinus exposed by disease, the location of the latter being rather far back. Posterosuperior wall was removed down to attic. Incisions in skin were not sewn up tight, and the usual skin flaps in the exetrnal meatus were omitted, because patient suddenly collapsed under anesthetic, and nothing was further attempted than the adjusting of the usual surgical dressings. Patient's general condition the next morning was fair, neck soft, not painful on pressure. Complained, however, of headache, had a short hacking cough without expectoration, and a rather staring expression about the eyes. Temperature that day ranged from 101 to 105½; pulse full, easily compressible and wanting tone. About 9 p. m. she had convulsive twitchings of the face and arms for five minutes, both sides being equally affected, according to the nurse. Resident physician responded to hurry call almost immediately and found patient semiconscious and pupils dilated. I saw patient myself about an hour afterwards. She was then perfectly conscious, and answered all questions intelligently. There was no aphasia. Movements of eyes, pupillary reflexes and eye grounds were normal; power of voluntary muscles of arms and legs was complete; surface sensibility good, and skin reflexes normal. During night, however, patient had no power over bowels or bladder, voiding both involuntarily. Four ounces of normal salt solution and ½ ounce whiskey were given every two hours by rectum. Next morning, May

2d, patient complained of severe pain in the left ear and left side of the head. About 11 a. m. she felt chilly without having a positive rigor. This was followed by temperature 105½, which dropped in three hours to 100, no profuse sweating taking place, though skin was moist. There was still the short hacking cough, without expectoration, and chest sounds were normal. At 3 p. m. the same day patient was put to sleep, with a view of uncovering the lateral sinus.

The mastoid wound cavity looked well, was granulating and apparently free from pus. Bone covering sinus was hard, of good color and free from fistula. There was no fistulous opening visible in the roof of the tympanum. In the vault of the wound cavity, corresponding to the roof of the antrum, was a defect in the bone about 4 by 5 mm. Dura here seemed quite good. With this as a starting point about two-thirds of the entire roof of the pyramid was removed, leaving the most medially situated one-third in situ. The removal of bone above and slightly anterior to the knee of the lateral sinus, revealed a large area of green gangrenous dura. Here pus was seen welling up between bone and dura. This extradural abscess was quite large, necessitating the removal of a good piece of the squamosa and the lower corner of the parietal bone. The dura was so altered in appearance that it was impossible to distinguish the dividing line between dura of middle fossa and that of posterior fossa or between dura of posterior fossa and sinus wall. In the center of this gangrenous dura was a fistula, emitting a small jet of pus with each pulsation of the brain. This fistula was enlarged with scissors, and a grooved director passed without resistance backwards and inwards into a more or less walled-off cavity, which seemed to be, judging from the anatomic relations of the parts and the fairly good view I got with my head mirror, the upper surface of the tentorium. After this subdural abscess had emptied itself the lips of the opening were held apart by a piece of gauze. Gauze was also placed between bone and dura. On the supposition that the subdural abscess was probably at the bottom of the entire trouble, patient was returned to bed without uncovering the sinus. Unfortunately no bacteriologic examination of the pus from the dural abscesses was made. For the next three days patient's general condition was quite good, appetite improved, color much better and

temperature ranged from 98 2-5 to 100½. She complained still of pain in the left ear and head. At 2 p. m. the following day, May 6th, she had a mild chill, followed by temperature of 105½. Eye grounds showed nothing pathologic. Although patient's general condition was much improved and the leucocyte count had fallen to 8,500, it was quite evident that all sources of infection were not removed and that the sinus, which was the original object of attack, but from which we had been diverted by finding pus accumulations on either side of the dura, was contributing a large share to the pathologic process. So on May 8th patient was again put to sleep. Two posterior skin incisions were made, one a continuation of the one made at the first operation, the second running up and backwards over knee of sinus. Dura was further uncovered upwards about 12 mm. and backwards the same distance. There was a smear of pus over surface of this portion of dura. The dura uncovered at the previous operation was now firmer. The fistula had entirely healed, the dura at that point being a little more prominent than surrounding parts. This little ballooning of dura was quite suspicious of pus retention, but the dura itself had improved so much in appearance that it was deemed wise not to reopen the fistula. The sigmoid sulcus, which was normal in color at previous operations, was now dark, and its removal ,exposed necrotic sinus wall, which enclosed throughout the entire length of the sigmoid curve a completely obstructing thrombus. The upper part of the thrombus plugged the sinus as high up as the knee, the lower portion plugged the vessel as low as the jugular bulb, while the middle part had disintegrated and formed a pus cavity which was only very imperfectly drained by a fistula through the sinus wall at the junction of the vertical and horizontal limbs. After the sinus wall was opened widely most of its interior was black with a film of gray over its inner surface. When the soft central portion of the thrombus was curetted away there was no bleeding from either end of the opened vessel. As the thrombotic plugs, which filled the median and distal ends of the sinus, were quite firm and seemed securely held in position, it was thought inadvisable to disturb them. A small tongue of bone on the roof of the petrosa corresponding to the course of the superior petrosal sinus was left in place to support the

brain. The opened sinus was packed lightly with iodoform gauze, as were also tympanum and canal; dura covered with gauze and wound left open. After this operation temperature became normal in 24 hours and remained so. The severe pains in the head ceased almost immediately, while those of the ear gradually subsided. Patient made a slow but good recovery, and at this writing is enjoying perfect health.

The case presents quite an array of interesting phenomena. Beginning with an otitis media from scarlet fever, the inflammation during fifteen years gradually invaded the mastoid with formation of cholesteatomatous masses in both tympanum and antrum. An acute exacerbation of a latent mastoiditis produced the illness which brought patient under observation. The most conspicuous symptoms at the first examination were those of mastoiditis, with septic thrombosis of the lateral sinus, and upon these the diagnosis of sinus complication was made. Sinus symptoms were practically unaffected by the exenteration of the mastoid and the opening of the dural abscesses. Severe head pains, usually in the left temporal region, but occasionally frontal, continued, together with chills and sudden elevations of temperature, until the sinus was opened and drained. That the systemic disturbance was not greater was probably due to the sealing of the lower portion of the sinus by a firm plug, preventing in this way the septic matter of the pus cavity in the middle of the thrombus passing en masse into the internal jugular. Whether or not there was any pathogenic cocci in the circulating blood was not determined, as no blood culture was made.

At the first operation it was our intention to investigate the condition of the sinus, but the unexpected collapse of the patient just after the mastoid cavity had been cleaned out rendered this impossible. At the second operation we were turned aside from the sinus partly by the normal appearance of the bone of the sigmoid sulcus and partly by finding the dural abscesses and wrongly attributing the clinical phenomena wholly to the subdural suppuration. In passing we may say that the case furnishes additional evidence of the pretty generally recognized fact in otology, that it is quite possible to have a destructive thrombophlebitis of the lateral sinus without a visible osteitis or necrosis of the sigmoid sulcus. It will be remembered that the bone over the sigmoid sinus was quite nor-

mal in appearance at the first and second operations, although the vessel was probably completely thrombosed at the time. Between the second and the third operation the appearance of the sigmoid groove changed materially, the purulent condition of the sinus wall beneath at last affecting the overlying bone. When the sinus was widely opened and the disintegrating center of the thrombus curetted away, the lumen of the incised vessel was so securely closed by plugs at both the median and the distal extremities that it was deemed unnecessary to remove them. Though it might have been safer to have ligated the jugular and then to have dislodged all portions of the obstructing thrombus, the recovery of the patient goes to show that ligation of the jugular is not absolutely necessary in every instance of complete obstruction.

The pachymeningitis was most likely the result of direct extension, the infection passing probably through the roof of the mastoid antrum. The suppuration was no doubt localized at first, giving rise to the extradural abscess. Contact of this collection of pus gradually softened the dura, which in time broke down, allowing the products of suppuration to pass to the inner side. How long the pachymeningitis interna had existed, it is impossible to say, but probably not long before it was arrested by free opening of the dura and drainage. The abscesses on either side of the dura were found united by a small fistula.

An interesting inquiry is whether the subdural suppuration gave rise to any clinical evidence at all. The only symptom referable to that cause was the short convulsion which occurred thirty hours after the first operation. A causal connection between the two is, however, by no means certain. In the present state of our knowledge of subdural abscess, it is safe to say that there is no pathognomonic sign of this condition, and that the diagnosis of such is made only at time of operation. Spinal puncture may be of assistance. Politzer says that as symptoms of circumscribed pachymeningitis interna are so similar to leptomeningitis, the dural sac should in the event of a negative spinal puncture be exposed and opened to prevent a diffused leptomeningitis.

With so much pus-laden dura in the vicinity of the superior petrosal sinus, one can hardly imagine how it escaped. If there was any involvement at all of this sinus, it was not de-

tected. On the day after the third operation both conjunctivae, especially the left, became injected, making one think of a possible beginning of the cavernous sinus. The eye grounds, however, were negative and the external appearance of the eyes returned to the normal in four or five days. That the labyrinth was not invaded is quite probable, as none of the usual symptoms were observed.

The recovery of this patient and of the majority of the cases already published and referred to in this paper would go to show that while subdural abscess is a grave complication of middle ear disease, it is far from being hopeless and may be completely cured by timely surgical interference.

512 Professional Building.

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LXIV.

FROM THE ANNUAL REPORT OF THE SANATORIA FOR TUBERCULOSIS IN THE UNITED STATES OF AMERICA AND CANADA.

By J. W. Gleitsmann, M. D.,

New York.

The great majority of the numerous sanatoria for tuberculosis in America issue no annual reports, and the reports issued by such institutions have only a limited circulation. By means of private inquiry, and especially through the friendly assistance of Dr. Jacobs, the secretary of the National Association for the Study and Prevention of Tuberculosis, a large number of these institutions was reached and thirty-two reports have, up to the present time (March 31, 1910), been received from them, among them the report of the U. S. Government. They do not all cover the same points nor end with the same months, and include varying periods of time, as all these institutions do not issue annual reports. The sanatoria are arranged according to the situation of the States in which they are located. Those classified under the name "State Sanatorium" are maintained by the State government and accept as a rule only poorer residents after an examination by a medical authority, who gives his opinion as to the prognosis, only curable cases and those in which a marked improvement is considered possible, being eligible. The name of the doctor is given in parenthesis. It was aimed to make this report as brief as possible, but in view of the fact that it is the first of its kind, it was considered desirable, in addition to data as to special equipment and therapeutic measures, to add information as to position, capacity, etc., points that can be omitted in later reports.

CANADA.

1. Gravenhurst (Ontario).—Muskoka Cottage Sanatorium and Muskoka Free Hospital for Consumptives (Dr. W.

B. Kendall). Eleventh annual report, September 30, 1907 to 1908. Both institutions on the lake of the same name, erected by and under the control of the National Sanatorium Association of Canada. The first named institution has room for 85 pay patients, lies in a park of 75 acres, has a main building with offices, three sun parlors, dining room, and rooms for 27 patients. There are in addition six cottages and ten tents. Of 220 patients, 128 stayed longer than one month, and of these (in the first and second stages) 41 were apparently cured or the disease was arrested. The second institution, for 75 patients without means, was recently increased by 32 beds. Of 172 patients in first and second stages who stayed longer than six weeks, 108 were apparently cured or the progress of the disease arrested.

2. Hamilton (Ontario).—Mountain Sanatorium (Dr. J. H. Holbrook). Under the control of the Hamilton Health Association. Fifth annual report, September 30, 1908-1909. Main building with offices, dining hall, a shack each for men and women, a third in course of construction. Capacity, 40 patients. Of 98 patients discharged during the year, having remained longer than one month in the institution; of 31 in the first stage, 19; of 22 in the second stage, 11—were apparently cured or disease arrested.

3. Toronto (Ontario).—Toronto Free Hospital for Consumptives and King Edward Sanatorium for Consumptives (Dr. W. J. Dobbie). These are the only two institutions in Canada which take advanced cases. The King Edward Sanatorium is for pay patients at moderate prices, and was opened Sept. 30, 1907. It consists of three buildings, administration, hospital, dining room with kitchen. Fifty-four patients have been admitted. The Toronto Free Hospital shows in its fourth annual report (1907-08) that 168 patients were received, 157 discharged, 54 improved. No one of these was in the initial stage, and, under the circumstances, the results were satisfactory.

VERMONT.

4. Pittsford.—Vermont Sanatorium (Dr. W. C. Klotz). Second annual report, 1909. Public sanatorium for early cases; others accepted if there is room. Capacity, 40 patients; price, $7.50 a week. Situated in the Green Mountains; 250 acres of wooded land; one main building, two cottages con-

nected with it by corridors. A third cottage, erected in 1909, rooms facing south. One hundred and eighteen patients treated during the year; 83 discharged, 37 of them in first stage, 18 apparently cured, 17 improved; 43 in the second stage, 4 apparently cured, 18 improved; 49 patients stayed longer than three months; 15 of them in the first stage, 13 of these apparently cured, in 2 disease arrested; 33 in second stage, 3 apparently cured, 14 disease arrested; of these last patients 12 were treated with tuberculin.

MASSACHUSETTS.

5. Rutland.—Massachusetts State Sanatorium (Dr. Fred L. Hills). Twelfth annual report, November 30, 1907-08. The first institution of its kind erected by a state. Elevation, 1,200 feet; accommodates 350. Radiating from the main building facing south and connected with it by corridors, are situated pavilions, including a sun parlor. Average number of patients, 339; average stay, 6 months 22 days. Of the total number of 619 patients, 16% apparently cured, 38% disease arrested; of 230 early cases, 33% apparently cured, 46% disease arrested; of 312 in second stage, 8% apparently cured, 37% disease arrested. Tuberculin frequently used for diagnosis, bouillon filtrate therapeutically. In the laboratory, investigation of such subjects as metabolism, opsonins, vaccines, etc. Inquiry as to the condition of the 4,311 patients treated up to December, 1907, gave the following results: 32.9% no answers, 26.7% died, 36.5% able to work, 3.6% not able to work.

6. Sharon.—Sharon Sanatorium (Dr. Walter A. Griffin). Eighteenth annual report, December 1, 1907-08. For women with moderate means in early stage. Elevation 300 feet; 150 acres; capacity, 23. A main building with southern exposure, with balconies on which the patients can sleep at nights. Of 40 patients discharged during the year, 19 apparently cured, 11, disease arrested. A number treated with tuberculin.

RHODE ISLAND.

7. Wallum Lake.—State Sanatorium (Dr. Harry Lee Barnes). Fourth annual report, 1908. On lake of same name. Capacity, 120; elevation, 600 feet; 250 acres. A main build-

ing, connected with it by corridors, two large buildings for patients, with sun parlors. The average duration of the stay of the 249 patients discharged during the year was 5 months and 20 days; 26 apparently cured, 73 disease arrested; 151 patients remained from 3 to 34 months; 20 of these in first stage; 13 apparently cured, 5 disease arrested; 119 in second stage, 13 apparently cured, 54 disease arrested. Tuberculin used for diagnostic and for therapeutic purposes. Inquiry showed that 32% of patients discharged in 1906, 37.6% of those discharged in 1907, and 86.5% of those last year were apparently cured or much improved and able to work.

CONNECTICUT.

8. HARTFORD.—Wildwood Sanatorium (Dr. Wm. B. Bartlett). Opened in 1905; annual report September 30, 1908-09. Connected with Hartford Hospital. Accommodates 50 patients in early stage. The institution lies high, consists of a main building, on each side of which is a ward for 25 men and 25 women, respectively, with a balcony on which the patients' beds may be rolled out for the night. During the year 115 patients were treated; 111 discharged; 10 of these apparently cured, 30 much improved. In a few cases Deny's tuberculin was used with good results.

9. WALLINGFORD.—Gaylor Farm Sanatorium (Dr. D. R. Lyman). Fifth annual report, May 1, 1908-09. Established by the New Haven County Association; accommodates 65 patients. Of the patients, 20% may be advanced cases. Elevation, 390 feet; 304 acres, 20 used as farm land. Main building, 4 cottages, with protected balconies on which the beds are placed. Of the 121 patients discharged during the year, 88 had remained longer than three months, and of 79 in the first and second stages 5 apparently cured, 43 disease arrested. Tuberculin treatment of 29 patients who stayed three months or longer gave good results. Inquiry as to the present condition of the patients treated from September, 1904, to January, 1909, gave the following gratifying results: Of 374 patients, 83% of the early cases, 56% of those in the second stage and 12% of the advanced cases were without subjective symptoms and able to be at their work.

NEW YORK.

10. Ray Brook (Adirondack Mountains).—New York State Hospial for the Treatment of Incipient Pulmonary Tuberculosis (Dr. Albert H. Garvin). Eighth annual report for the year 1908. Elevation, 1,625 feet; present capacity, 164. The waiting list is larger than the number of patients, and an increase in the number of beds to 300 is very necessary. Area of more than 500 acres; large adjacent forests. There is an administration building, on each side of this a sleeping pavilion and two smaller buildings. Of 298 patients, 217 stayed longer than three months; 99 apparently cured, 62 disease arrested. Treatment consists of proper diet, exercise and fresh air, the details having been given in a former report.

11. Lake Kushagua (Adirondack Mountains).—Stony Wold Sanatorium (Dr. Hy. S. Goodall). Eighth report, for the year 1908. Plans for 150 patients; present capacity, 95. For women in early stage and for a limited number of children, for whom there is a school. During the year 22 children as patients. Near the lake, spacious grounds, with orchards and vegetable gardens. Main building, with offices, dining room, two large sleeping chambers with 25 beds each. Three pavilions built during the last year, and a laboratory. Twenty lodges (members only women) help toward defraying the expenses. During the year 224 patients treated, 135 discharged, six of these without any demonstrable tuberculous lesion; of 105 women 53, of 24 children 19 apparently cured or disease arrested.

12. Liberty.—Loomis Sanatorium (Dr. H. M. King), named after the late well-known New York clinician Alfred L. Loomis. Thirteenth annual report, October 31, 1908-09. Elevation, 2,300 feet; just south of a range of hills, which afford protection. Three separate classes, varying in price; first the sanatorium proper, with a main office building, with parlors, a building for the reception and observation of new patients; second, a building for patients of the middle class, with 14 beds; third, patients unable to pay, with 40 beds. In the medical report attention is called to the necessity for, and the plans already made, for enlarging the laboratory and for increasing the facilities for investigative work. During the year work was done on the blood serum of tuberculous patients compared to that of healthy individuals, and on the chemistry and bac-

teriology of the secretions. Tuberculin treatment in a large number of cases gave good results. Of 205 patients in the first two divisions, 32 were apparently cured, in 44 disease arrested. Of 119 patients in the third class, 26 were apparently cured, in 35 disease arrested.

13. New York.—(a) Montefiore Home for Chronic Invalids (Dr. Siegfried Wachsman). Twenty-fifth annual report, September 30, 1908-09. Large stone building in a garden, taking in a city block, in the northern part of the city, which lies high. Free for chronic invalids; about 50 beds for tuberculosis patients. During the year 472 patients were treated; 57 of these consumptives, of whom 3 were apparently cured and 9 improved. The institution cannot accommodate even a small part of those who desire admission, and the erection of a larger building in the country is contemplated.

(b) Bedford Station.—Montefiore County Sanatorium (Dr. J. Rosenberg). Opened 1897. Under the same direction as the above; 40 miles from New York. Elevation, 450 feet; 150 acres; capacity, 180; free for poor patients in incipient stage. Four two-story buildings, connected by corridors; southern exposure; sun parlor. During the year 512 patients were treated. Of 178 in the first stage, 29 were apparently cured, in 55 the disease arrested. Of 85 more advanced cases, 1 was apparently cured, 14 improved.

14. Saranak Lake.—Adirondack Cottage Sanatorium (Dr. E. L. Trudeau). Twenty-fifth annual report, October 31, 1908-09, together with a memorial celebrating the 25th year of its existence. (See end of paper.) This is no place for a complete history of the institution, but a few facts as to its early days will be interesting. The late Dr. Loomis was the first one to recognize the advantages of the climate of the Adirondacks, and it was he who persuaded Dr. Trudeau to settle there. He had at first three small wooden buildings accomodating 12 patients. The rooms were heated with small stoves and petroleum furnished the light. There are now 25 buildings, a main building, 21 cottages, hospital, and library, and 110 patients can be taken care of. Elevation, 1,650 feet; one mile from the lake; $7 a week, and a fund to pay for free beds (37 patients last year). Through the liberality of the patrons a building has been added almost every year. A separate medical report gives the history of each case. During

the year 300 patients were treated, 190 discharged. Of these 38 were apparently cured, in 102 disease arrested, 37 improved. One hundred and sixty-four patients stayed longer than three months; of these 62 were in the first stage; 28 apparently cured, in 25 disease arrested. Of 97 in the second stage, 8 were apparently cured, in 63 the disease arrested. Of those who remained longer, 96 were treated with tuberculin; 32 in first stage, 11 apparently cured, in 17 disease arrested; 61 in second stage, 4 apparently cured, in 41 disease arrested. The report as to the present condition of 421 patients treated with tuberculin from 1901 to 1908, is as follows: The whereabouts of 79 unknown, 95 dead, 126 living, 192 well. Of 2,691 patients of the years 1885-1908, 1,041 are in good health, 308 living, 1,099 dead, 252 information lacking.

PENNSYLVANIA.

15. MONT ALTO.—State South Mountain Sanatorium (Dr. A. M. Rothrock). First annual report, May 31, 1907-08. Begun in 1907, after appropriation by State. Capacity, 350, but being enlarged for 250 more. Elevation, 1,600 feet; 500 acres; 41 buildings, each with 4 rooms, to accomodate two patients. Of 81 patients discharged during the year in the first and second stages, 37 were apparently cured, 35 improved. A serum prepared by Dr. Dixon, a State health officer, was used in a number of cases with good results.

16. SCRANTON. West Mountain Sanatorium. Sixth annual report, for 1908. Under the direction of the Scranton Society for the Prevention and Cure of Consumption. For poor of the city, free; for others, $5 to $7. Capacity, 24; 60 acres, under cultivation. Elevation, 1,500 feet; two walls, one for men and one for women, with ten beds each. Six shacks, each for two patients. Of 29 patients discharged during the year, 2 were apparently cured, 27 improved.

NORTH CAROLINA.

17. ASHEVILLE.—Winyah Sanatorium (Drs. Carl and Silvio v. Ruck). Report for 1907 and 1908. For 80 pay patients. Opened in 1888. Situated in a park. Elevation, 2,000 feet. Large main building of stone, with spacious porches on each of the two floors, which can be closed up neces-

sary. Well-equipped laboratory for investigative work and the preparation of the watery extract of tubercle bacilli used in the institution. Of 337 patients discharged during the two years, 75 were in the first stage; of these, 55 were apparently cured or improved; the same result occurred in 88 of 135 in the second stage, and 54 of 127 in the third stage, a total of 197. Of these 197, 159 were apparently cured, in 38 disease arrested. Average duration of treatment, 168 days. The following figures show the good results obtained with the above mentioned tuberculin preparation: Of 782 patients, from 1888 to 1898, without specific treatment, 11.9% were apparently cured, 30% improved; of 1,503 patients treated with the extract, 55.5% were apparently cured, 33.8% improved.

MISSOURI.

18. MOUNT VERNON.—Missouri State Sanatorium (Dr. John Stewart; Medical Director, Dr. Wm. Porter). Opened August 1, 1907. Report ends with January 1, 1909. Elevation, 1,400 feet; 200 acres for gardening. The officials planned stone buildings with additions as appropriations were made by the State. It is intended to have eight one-story buildings, each for 24 patients, half men, half women; four buildings for the administration, medical purposes, help. At present there are two buildings, which accommodate 50 patients. Histories of each of the 135 cases treated, which show that all but 9 were improved.

ILLINOIS.

19. NAPERVILLE.—The Edward Sanatorium (Dr. Theo. B. Sachs). Second annual report, for 1908. Under the direction of the Chicago Tuberculosis Institute. Can accommodate 35 patients at reasonable rates. Plans to enlarge to 100 beds. There are being built now a building for medical purposes, a laboratory, and a hospital for ten patients. Of 98 patients discharged during the year 55 were in first stage, and of these 20 were apparently cured, in 22 disease arrested; of 31 in second stage, 10 were apparently cured, in 18 disease arrested. In 1907, 12 patients; in 1908, 22 were treated with Deny's tuberculin.

IOWA.

20. OAKDALE.—State Sanatorium for the Treatment of Tuberculosis (Dr. H. E. Kirschner). Opened February 1, 1908. Report up to June 30, 1908. Two hundred and eighty acres farming land. Capacity, 80; to be enlarged. Main building, with two pavilions, with two wings each. Each pavilion has a balcony and ten rooms, each for two patients. There were received 105 patients; discharged, 60; in 1 disease arrested, in 41 improvement. Tuberculin treatment.

MICHIGAN.

21. HOWELL. Michigan State Sanatorium (Dr. R. L. Kennedy). Opened September 1, 1907. Report up to June 30, 1908. Elevation, 1,100 feet; 272 acres farming land. Present capacity, 48; to be enlarged to accommodate 100. Main building with dining room for 125, and annex with 8 beds for very sick patients; three shacks, one for eight and two for ten patients each. Medical report up to December 1, 1908, shows 104 patients admitted, 68 discharged; 13 of these apparently cured, in 14 disease arrested.

MINNESOTA.

22. WALKER.—State Sanatorium for Consumptives (Dr. W. J. Marcley). Opened December, 1907. Report ends with July 31, 1908. Near a lake; 740 acres. At present two halls and two cottages for 60 patients. Although intended for patients in early stages, many advanced cases were admitted. Of 56 patients discharged, 2 of those in the first stage were apparently cured, 11 improved; 16 of those in the second stage and 15 of the more advanced cases, improved.

23. PINE CITY.—Pokegama Sanatorium for Incipient Cases of Pulmonary Tuberculosis (Dr. C. B. Tiesberg). Report for 1908-09; fourth annual. On a peninsula on South Lake and Lake Pokegama; for pay patients. The first two years only during the summer. Present capacity, 88; several shacks. The results in winter better than those during the summer. Of 67 patients, 15 were in first stage, 1 of these apparently cured, in 5 disease arrested, and 8 improved; of 17 in second stage, 2 were apparently cured, in 2 disease arrested, and 8 improved. Tuberculin used in most of the cases.

NEW MEXICO.

24. FORT BAYARD.—U. S. Army General Hospital. For officers and soldiers of the regular army. Report for the year 1908. Elevation, 6,165 feet; capacity, 400. An administration building; eight rooms, for 15 officers, are being completed. Of 618 patients treated in 1908, 85 were in the first stage, and of these 16% were apparently cured, in 27% disease arrested; 338 in second stage, 5% apparently cured, in 18% disease arrested. Three hundred and thirteen stayed six months or longer. 68 in first stage, with 19% apparently cured, in 29% disease arrested; 170 in second stage, with 6.5% apparently cured, in 28% disease arrested.

25. FORT STANTON.—Sanatorium for Consumptive Seamen (Dr. H. S. Mathewson). Report June 30, 1907-08. Free, exclusively for tuberculous sailors, supported by the U. S. Government. Reservation of 43 square miles, on which the cattle and horses for the institution are raised. Elevation, 6,230 feet. More than 20 stone buildings; 90 tents, which the patients all prefer. Capacity, 250; admitted, 183; discharged, 175; 1 cured, 13 apparently cured, in 39 disease arrested, 23 improved. For three months 30 patients were treated with deep injections of Hg., but the method was abandoned because no good results were seen. Tuberculin given internally; results more encouraging. Thanks are due the Surgeon General and Commanders of the forts for these two reports.

26. SILVER CITY.—St. Joseph Sanatorium (Dr. Oliver T. Hyda). Founded 1901 by a religious order; 35 patients; report without dates. Elevation, 6,000 feet; main building, with court, one story, one room deep; each room has two balconies, one used for sleeping. A building for patients in advanced stage. Of those in first stage, 71% apparently cured, in 29% disease arrested; of those in second stage, 23% apparently cured, in 42% disease arrested.

COLORADO.

27. COLORADO SPRINGS.—Union Printers' Home (Dr. W. L. Christopher). Report May 31, 1908-09. Founded 1898. Free for five-year members of the International Printers' Union; not exclusively for tuberculosis. Tuberculous patients in any stage to the number of 80. Large main building with

one wing, hospital. Medical report shows that 17 tuberculous patients, after a stay of from 29 days to 2 years and 5 months, were discharged able to resume work.

28. DENVER.—National Jewish Hospital for Consumptives (Dr. Moses Collins). Ninth annual report, April 30, 1908-09. Free for 135 poor patients; non-sectarian. Elevation, 5,200 feet. Main building, with offices, library; two wards with 12 beds each; operating room, chemical and bacteriologic laboratory; a pavilion for 35 patients, and one for women with 16 sleeping rooms. Very complete medical report, with many charts. Of 223 patients discharged, 113 were in early stage, and of these 24 were apparently cured, in 40 disease arrested. Average stay, 177 days. Charts for each case in which the conjunctival, cutaneous and subcutaneous methods for diagnosis were used. Data as to the results with bacillary emulsion, vaccine and mercury. Of 23 cases treated with mercury, in 1 disease arrested, 2 improved.

29. EDGEWATER (near Denver).—Evangelical Lutheran Sanatorium (Dr. Wm. N. Beggs). Founded 1905. Report April 30, 1908-09. Capacity, 33; moderate prices; patients in all stages. Main building of wood, with offices, dining room and rooms for officials; a group of small tents and a large tent in which the patients congregate for pastime. Of 102 patients, 58 were improved. Tuberculin and mercury were used in selected cases.

30. SANATORIUM of the Jewish Consumptives' Relief Society (Dr. J. B. Fish). Fifth annual report, for 1908. Free for poor patients in all stages. Capacity, 80. There are in the various States 20 associations which contribute toward the support of the institution. Four buildings, 32 tents; farming. Of 147 patients, 28 in the first stage 71 in second, were discharged, in 7 disease arrested, 91 improved.

CALIFORNIA.

31. LOS ANGELES.—Barlow Sanatorium (Dr. R. J. Cunningham). Sixth annual report, September 1, 1908-09. For poor patients who have been in the country one year. In a large park. Capacity, 33. Administration building, sleeping quarters and 9 cottages, accommodating 18 patients; Laboratory. Of 66 patients, 14 in the third stage, 2 were appar-

ently cured, in 6 disease arrested, and 28 improved. Several patients treated with tuberculin.

32. Monrovia.—Pottenger's Sanatorium for Diseases of the Lungs and Throat (Drs. Pottenger and Browning). Report for the years 1906-08, inclusive. The leading sanatorium in the West; elevation 1,000 feet, in the spurs of the Sierra Madre; park of 40 acres. Capacity, 100 pay patients. Large administration building, with parlor, dining room, 20 rooms for patients. In addition, 62 bungalows, with or without bath, well-equipped laboratory, separate rooms for laryngeal cases. In the three years 447 patients were discharged, of whom 152 stayed less than three months, and are not included in the medical report. Of the others, 26 were in the first stage, of whom 23 were apparently cured, and in 3 disease arrested; of 35 in second stage, 20 were apparently cured, in 9 disease arrested; of 234 in third stage, 21 were apparently cured, in 56 disease arrested. A table shows the condition of 206 patients treated in 1906 and 1907, at the time of their discharge and at present. When discharged 46 were apparently cured, in 49 disease arrested, 80 improved; of those apparently cured, 42 are now apparently well; of the 49 reported as disease arrested, 12 are apparently cured, in 33 disease has been arrested; of the 80 improved, 4 are apparently well, in 13 disease arrested.

*Note to No. 14.—This sanatorium is the oldest of those now in existence, but not the first established. The compiler of this report on July 1, 1875, established a small sanatorium in the little village of Asheville, North Carolina, in the mountains. The sanatorium was conducted for six years according to Brehmer's principles. Inability to erect a larger and better building and the inconveniences of travel at that time caused the founder to give up the sanatorium. The report of the first two years appeared in Baltimore in 1877 and showed the following results: Of 12 patients in the first stage 11 were apparently cured or the disease arrested; of 14 in second stage, 3 were apparently cured, or the disease arrested.

LXV.

A CASE OF BRAIN ABSCESS WITH RARE OCULAR SYMPTOMS.

By C. Barck, M. D.,

St. Louis.

The patient, Mrs. V. C., was seen by me for the first time on the 10th of January, 1910. She had been married for two years, but had no children. One brother and two sisters are living and healthy.

Previous history: Patient had a congenital, slight facial paresis on the right side. It had been noticed by her parents, soon after she was born. Since childhood she was suffering from a chronic otorrhea of the left ear. This was attended to at times, but in the main neglected. There was no pain in the ear, until the beginning of 1909. The pain increased by and by, and became very severe in March and April of the same year. The discharge was copious and in May the mastoid region commenced to swell. On the 26th of May a mastoid operation was performed at her home in the country. But, after the first week, the severe pain reappeared. It was located at that time mainly in the back of the head and neck. On account of this persistent pain, a second operation was performed two weeks later. The physician who was present during the procedure stated that a kind of radical operation had been done and that the ossicles had been removed. But the pain in the head continued. It was felt partly in the forehead and partly in the occipital region. Soon after the second operation vomiting set in, and during a period of three to four weeks the patient vomited after every meal. Then it gradually subsided.

One week after the second operation, the patient noticed that her vision was impaired; but no examination was made at that time. She stated that the condition was a changeable one; that at times she could see quite well, then again everything would appear dim. Since September, 1909, a decided

diminution in the visual acuity took place, and six weeks prior to her consultation with me she noticed—and her family physician found on rough examination—that she had hemianopia. She was not able to see within the right half of the field of vision. Patient was still able to read on the 1st of November, 1909, but not since.

Examination: No discharge from ear. Large, dry cavity. Drum membrane and ossicles wanting; but the posterior wall in its entirety present, proving that no radical operation could have been performed. In the mastoid region a large, irregular scar, somewhat depressed. No fistula; no redness around the scar. No pain on moderate pressure. Generally speaking, it was the condition we find after the healing of a mastoid operation. But there was one spot, about one inch above and one inch behind the scar, which was very painful to pressure, as well as to percussion with the style (a method recommended by me some years ago). The painful area was an irregular circle, with a diameter of about two-thirds of an inch. On repeated examinations by different observers, this painful site was invariably discovered. It corresponded to about the hinder portion of the temporal, or to the foremost portion of the occipital lobe.

Spontaneous pain was not experienced within this area; but was located farther back in the occiput. There was no pronounced stiffness in the muscles of the neck, but movements of the head, especially forward or bending movements, were very painful. There was no dizziness and never had been. Examination of the labyrinthine functions proved them intact.

The vision of the right eye was 1/60; that of the left 1/36; could read none of Snellen's test types. There existed complete right homonimous hemianopia. The division line was vertical, passing through the point of fixation. There was no palsy or paresis of the external ocular muscles. The ophthalmoscope revealed a choked disk of considerable degree in both eyes. The difference between the height of the swelling and the surrounding retina was measured as 3 diopters, corresponding to an elevation of 1 mm. In the left eye there were two large hemorrhages close to the optic papilla, one of them having a diameter as large as that of the disk. No hemorrhage in the right eye.

The paresis of the right facial nerve, mentioned in the anamnesis, was of a moderate degree. It was confined to the lower branch of the nerve, controlling the muscles around the mouth, and became most apparent when the patient laughed. The upper branch, controlling the orbicularis muscle, was intact. Relatives made the statement that this paresis had become more manifest the last month (which statement was at the time accepted "cum grano salis").

Speech and memory were not affected. The patient spoke fluently, rather rapidly. She answered all questions in a precise manner. Her physician stated that in June her memory had been somewhat defective; that she could not remember names correctly; but the report was too vague to be of any value. The mental state of the patient, however, was an abnormal one. It was one of labile psychic equilibrium. As a rule she was very much depressed and wept frequently. Moreover, she was very excitable, so that the examination had to be interrupted at times.

During the next few days of observation the pulse rate varied between 80 and 100, whilst the temperature was always found to be normal.

I made the diagnosis of an otitic brain abscess in the left temporal lobe, reaching far back, so as to encroach upon the optic radiation (Gratiolet's visual fibres) in the posterior part of the capsula interna. The symptoms seemed to me sufficiently clear to assume the presence of a cerebral abscess, and the only question to my mind was that of the differential diagnosis between the location in the temporal lobe or in the cerebellum. Hemianopia could be the consequence of a lesion in either; in the first instance by affecting the optic radiation or the optic tract; in the second by injuring the cortical center in the occipital lobe, either by transmitted pressure or by direct destruction after perforation of the tentorium. Such a case is on record. The fact that the dividing line between the preserved and the destroyed halves of the fields of vision passed through the point of fixation, may have been accepted in favor of the former view. For, according to some authorities, the dividing line, in lesions of the optic tract, is a vertical one, and the central vision, in consequence, materially impaired. In lesions beyond the primary centers (geniculate bodies) the dividing line passes in a curve around the center

of the field, so that the macular region is spared and the central vision very good, often normal. This theory, however, is not yet generally accepted; and, furthermore, the presence of the enormous choked disks complicated and obscured the clinical picture to such an extent, that I did not feel justified to draw any conclusions from these findings of the perimeter.

My diagnosis of a localization in the temporal lobe rested mainly on the following points: The circumscribed area, which was so decidedly painful to percussion; the want of cerebellar symptoms, as ataxia, dizziness, etc., and the absence of suppuration of the labyrinth. At first, on noticing the facial paresis of the right side, I thought that this symptom might also be used for topic diagnosis, speaking again in favor of localization in the temporal lobe, but after learning that it was congenital, it had to be left out of consideration.

During the following days a number of consultations were held with an oculist, Dr. J., and a neurologist, Dr. G. The opinion of the former coincided with my view, but the latter, whilst not denying the possibility of a suppurative process, maintained the probability of a chronic encephalitis, basing his opinion mainly on the congenital paresis of the facial nerve. Yet, under the existing circumstances, he considered an operation justified.

Operation: Performed on the 14th of January. The section was made through the old scar and continued upward and backward. In the exposed mastoid there were still some small carious foci; but the bone was generally firm. The posterior wall, towards the cerebellum, consisted of perfectly healthy, dense bone. The supramastoid crest, the tegmen antri and the posteroinferior portion of the squama of the temporal bone were then removed, to expose the middle cranial fossa. The bone of these regions was enormously sclerosed and hard like ivory, requiring tedious work with the bone forceps. An area of the dura, about one inch in diameter, was laid bare. The upper and hinder portion of this exposed area showed a spot of marked discoloration, which corresponded quite closely to the painful site found on percussion. After incision of the dura, the brain substance bulged out under considerable pressure. At the spot mentioned, the dura was adherent to the cerebrum. The tem-

poral lobe was then explored, partly with a long narrow knife and partly with a trocar. I introduced the instrument about twelve times in different directions, going in as far as 6 cm. Special care was taken to go backward and upward as far as permissible, and I came in contact with the tentorum several times. But no pus was encountered. A drainage tube, 5 cm. long and 1 cm. in diameter, was inserted, and the usual dressings applied.

The subsequent course, for the first four weeks after the operation, was a very favorable one. The immediate effect of the release of the intracranial pressure was remarkable. The pain in the head disappeared completely and the entire mentality of the patient became changed. The psychic depression had given way to a happy, at times even hilarious, disposition. She was convinced that she would recover. There was no rise of temperature; sleep and appetite were excellent. The fundi were examined every few days; three days after the surgical interference a considerable decrease in the size of the choked disks was noticed and they gradually became smaller during the following weeks. Within this period the vision of the left eye improved to a certain extent, so that the patient could read Snellen XII and later on XI with difficulty. The sight of the right eye did not improve materially. The hemianopia remained always the same.

On the second dressing it seemed that there was some pus in the tube; but none could be discovered subsequently. As was to be expected, a cerebral prolapse of medium size formed. This had to be clipped on two different dates, on the 24th of January and on the 9th of February.

The patient had been out of bed for some time, when a gradual change in the clinical picture took place. On the 7th of February the temperature rose to 100 and kept on rising during the following days, reaching 103-104. The headaches reappeared, becoming so severe as to necessitate the administration of anodynes. On the morning of the 14th there was loss of speech (amnesic aphasia). Then coma set in, which increased rapidly until the exitus letalis on the 18th of February.

Postmortem: The brain was removed and upon the advice of Dr. G. put into formol solution, to be cut into sections afterwards. There was a moderate degree of leptomeningitis,

more pronounced over the left side. Furthermore, there was a fresh hemorrhage in and around the Sylvian fissure. Whether or not an abscess of the brain was present, could not be determined at the time of removal. When the specimen was sectioned, ten days later, by Dr. G., Dr. Th., pathologist, and myself, a cerebral abscess was found. It was relatively small, about three by four cm. in diameter, and surrounded by a thin capsule, which was partly broken. The pus was almost odorless. Whether this was due to the formol or whether it had been inoffensive primarily, I am unable to state. The abscess cavity was located in the extreme posterosuperior portion of the temporal lobe. After placing the sections of the brain together, we measured the distance of the abscess from the point of incision, and found it to be 6½ cm. I am, of course, aware of the fact, that after these manipulations with the specimen, the findings are only approximately correct; yet we were very careful to restore the normal condition as far as possible.

Remarks: The clinical picture was somewhat obscured by the fact that the crossed facial paresis was a congenital one. Had it been acquired it would have been a valuable symptom, proving a lesion of the capsula interna. It furthermore weakened to a certain degree the conclusions which could be drawn from the hemianopia. The subsequent improvement of the paresis placed the mentioned statement of the relatives in a different light; and the inference from this improvement in view of the autopsy is, that the previously existing paresis was increased by the pressure of the brain abscess and improved after this was relieved. But apart from the facial paresis, the hemianopic symptoms were so definite, that I assumed, on this basis, an encroachment on the visual radiation in the capsula interna. In spite of the vertical dividing line of the field of vision, I did not consider an affection of the optic tract probable. I furthermore concluded that the abscess must be a very large one, in order to reach so far back. Moreover, this conclusion seemed to be corroborated by the enormous degree of the choked disks, such as I have never seen before in brain abscess.

There are about twelve cases on record in literature, where otitic abscesses of the temporal lobe caused hemianopia. But in none of them is it stated, whether the dividing line of the

field of vision passed through the very center, or whether the macula was spared.

The retrogression of the choked disks after the release of the intracranial pressure was a very rapid one; and if conclusions may be drawn from a single experience, this would speak in favor of the "pressure theory," against the "toxin theory" of choked disk. Since the one factor, the tension, was removed by the operation, whilst the other, the abscess, remained undisturbed, the lesson learned from the case is equivalent to that of a physiologic experiment.

Otitic cerebral abscesses are, as a rule, found close to the primary focus in the bone. In this case the distance was unusually far, and even the path of infection could not be detected at autopsy. There is but a single case on record of an abscess at the distance of 7 cm. from the surface, which was found and opened surgically; the termination was fatal, because of the impossibility to establish proper drainage. For this very reason, I believe, that also in my case the outcome would have been the same had the abscess been opened. The advice given by Koerner and others is: not to enter with instruments farther than 4 cm., in order not to injure the lateral ventricle. As previously stated, I introduced the knife considerably farther. During the after-treatment I felt inclined to probe once more, but as I had about abandoned the diagnosis of a suppurative process, I considered it contraindicated. The aphasia, which occurred shortly before death, is, of course, explained by the recent hemorrhage in the region of the Sylvian fissure, affecting the center of speech.

ABSTRACTS FROM CURRENT OTOLOGIC, RHINOLOGIC AND LARYNGOLOGIC LITERATURE.

I.—EAR.

Report of One Hundred Radical Mastoid Operations.

WELTY (*Cal. State Journal*). There were eighteen cerebral complications in this series, of which two died. Both in extremis before the operation. He has had, therefore, no proper operative mortality at all, a most satisfactory report. There were seven preoperative cases of facial paralysis, all of which recovered except the fatal case. In one very interesting case, all individual cells in the mastoid were filled with cholesteatomatous masses. Fifty per cent of the cases were cholesteatomatous. Welty promises all patients with a hearing distance for whispers of 1-6 feet before the operation a certain improvement in the hearing distance as a result of the operation. Fifty-seven cases were improved in hearing, twenty-six remained the same, six were made worse, three cases lost to observation, five still under treatment. His favorable results he attributes to his method of skin grafting, the details of which will be shortly published. Forty-seven cases were completely dermatized under eight weeks. His recent cases show marked improvement over this time.

Horn.

The Determination of the Upper Tone Limit.

HEGENER, Heidelberg (*Monatschrift fuer Ohrenheilkunde*, Bd. 44, 1910, pp. 749). In a paper read before the last German Otological Congress, Hegener has repeated his experimental work of two years ago, and comes again to the conclusion that the upper tone limit of hearing in human beings is in the neighborhood of 20,000 double vibrations. This is only in the case of individuals who are specially trained to hear high sounds, the ordinary individual can appreciate but 17,000. The findings of the earlier investigators, whose results varied from 27,000 to 66,000, are carefully reviewed. Their methods were again tried, and in the light of modern physical research, especially by a method which Hegener has himself invented, of determining vibrations by

means of the gas flame, there seems to be no doubt that the results of the earlier investigators were too high, and were the result of faulty technical means of experimentation. In this he has the support of Prof. Karl Schaeffer, of Berlin, and Prof. Shultze, of Marburg, so there can be no question of the accuracy of his results.

His statement of two years ago, that the Galton whistle, as constructed by Edelmann, was to be cast aside as a method of examination, caused then a profound sensation, and, in spite of the efforts of that great Munich physicist, his newly constructed whistle, with the valve for controlling the air pressure, has proved by these last experiments of Hegener, to be almost as faulty as before. He repeats, that the monochord of Schultze is the only instrument that can be depended upon for the determination of the upper tone limit. As is well known, this instrument is nothing more than a piece of steel wire stretched between two posts about 50 cm. apart at a certain tension. A clamp enables us to divide the wire into any length, and a scale on the side makes it possible to read off the number of vibrations and the note. It was originally manufactured only by Görs, who is Prof. Schultze's mechanician in Marburg, but can now be obtained from Pfau in Berlin and at the Edelmann institute in Munich.

Horn.

Cholesteatoma and Its Relation to Otogenic Meningitis.

Danelon, Triest (*Monatschrift fuer Ohrenheilkunde*, Vol. 44, 1910, p. 760). During the years 1908 and 1909 there were received in Prof. Urbantschitsch's clinic, in Vienna, 36 cases of meningitis, 14 cases followed an acute otitis, 22 followed chronic suppuration. The 22 cases of meningitis following the chronic process were divided as follows:

(a) Ten cases occurred without the presence of cholesteatoma: 2 cases of tuberculous meningitis; 1 case purulent meningitis of the base with pachymeningitis interna; 2 cases of sinus thrombosis with intensive extradural abscess; 2 cases of purulent labyrinthitis; 2 cases of abscess of the temporal lobe; 1 case of a large sequestrum.

(b) Twelve cases occurred complicated with cholesteatoma: 1 case of temporal lobe abscess with fistula of the horizontal canal; 3 cases of temporal lobe abscess; 1 case of

temporal lobe abscess with purulent labyrinthitis; 3 cerebellar abscesses; 3 cases of labyrinthitis; 2 cases of sinus thrombosis.

In conclusion, one must always take into consideration the cause of the meningitis, whether it follows an acute otitis, a chronic suppuration, or a chronic suppuration complicated with a cholesteatoma. In the acute process the meningitis takes place by direct contact. In the cases complicated by a cholesteatoma the infection follows secondarily on an intracranial complication. The ordinary suppurations occupy a middle place. The practical result of this paper is the fact, that given a case of suspected meningitis, where by the operation we find a cholesteatoma, we must not abandon the operation until we are absolutely satisfied that no intracranial complication exists. This means a systematic inspection of the sinus and the dura of both the anterior and posterior cranial fossae. *Horn.*

II.—NOSE.

A Comparison of the Oral and Nasal Methods of Operating on the Nasal Septum.

HALLE, Berlin (*Monatschrift fuer Ohrenheilkunde,* Vol. 44, 1910, p. 826). In these ANNALS for June, 1909, the reviewer sharply criticised Kretschmann's method of operating for a deviated septum through the mouth. Since that time he has seen nothing in the American literature on the subject, so concludes that it has not yet been tried in America. That it was received with some degree of consideration in Germany is evident from the present long article of Halle, who considers it necessary to compare the two methods. It is certainly remarkable how many indications have been found for it. Loewe finds the operation called for:—

1. In babies and children in the first year of life.
2. In the so-called vertical fracture of the septum, as soon as a misplacement of the anterior fragment has taken place.
3. In correcting crooked bridges, where the cause is due to a broken septum.
4. Where, on account of processes such as thickening of the floor of the nose, spines, and deformities of the crista incisiva, etc., one has not room to work.
5. Specialists who have had little opportunity to carry out the submucous operation in difficult cases.

Supposedly following these indications he has operated 53 cases, but I am unable to find out how many were under one year of age.

Halle made a careful study of the operation on the cadaver and comes to the conclusion that practically every indication which Loewe gives is more than overbalanced by the overwhelming disadvantages of the method. The general narcosis, the long wound, the severe hemorrhage, and the long after-treatment are disadvantages which the possible greater field of vision scarcely compensates for. *Horn.*

Two Cases of Fatal Meningitis Following the Killian Operation.

JACQUES (*French Oto-Laryngological Society Proceedings,* 1910). Two apparently favorable cases for operation died forty-eight hours after the procedure of fulmanant meningitis. The autopsies showed no dehiscence of the bony walls. He considers that the operation should only be carried out in the interval between attacks of pain, and that the region around the upper turbinate, the cribriform plate and the upper part of the septum must be carefully avoided.

Horn.

The Nasal Reflex Neuroses.

GUSTAV KILLIAN (*Deutsche medicinische Wochenschrift,* No. 40, 1910). The nasal reflex neuroses originate as the result of an excessive sensitiveness of the nasal mucous membrane, particularly with such forms of irritation causing tickling. Even the slightest local, regionary or remote reflexes may bring this about, and for this reason reflex neuroses may easily develop.

For the clinical demonstration of the subject, it is important to divide the neuroses into three classes, ethmoidal, sphenoidal and olfactory. A therapy based on such a division may be very effective, and this is particularly true of the local therapy. Leaving out of account the removal of nasal stenoses and chronic inflammatory processes of various kinds, the most rational treatment is, first of all, to investigate parts of the nose that are hyperesthetic, because the reflexes start in such regions. It is also of great importance to determine what variety of nasal reflex neurosis exists, and it is not uncommon to have mixed forms.

Testing the hyperesthesia of the nasal mucous membrane will show us whether our treatment will have to be applied anteriorly or posteriorly, or to both regions. For a temporary quieting of the nerve endings we may use cocain, and for superficial destruction, caustic agents, such as trichloracetic acid and chromic acid. For deeper cauterization, electrolysis and the cautery may be used. Better results will follow extirpations of the hyperesthetic areas of mucous membrane, which are common, particularly when chronic hypertrophies of the inferior turbinate must be removed at the same time.

In ethmoidal neuroses, the writer has taken special care to remove irritable zones in the anterior end of the inferior turbinate. In sphenoidal neuroses, the hyperesthetic region in the middle and posterior end (high up) of the inferior turbinate should be removed.

For the temporary cure of ethmoidal neuroses, the writer several years ago, recommended cauterizing the "four points" with trichloracetic acid.

In old and stubborn cases of ethmoidal neuroses, the unilateral and bilateral resection of the ethmoid nerve, by way of the orbital cavity, has been recently and successfully first performed by Eugen Jonge. Neumeier and Bloss followed him, and the author has also had a successful case.

The author has recently, instead of performing this operation under general anesthesia, been doing an intranasal resection with cocain and adrenalin. The septal branch is easily reached, and the lateral branches, slightly above the anterior end of the inferior turbinate, are also accessible. The septal branch of the sphenopalatine nerve can be reached above the upper edge of the choana. The branches that extend to the inferior turbinate posteriorly can be reached with a properly curved knife. Olfactory neuroses cannot be treated in this way. Caustics are contraindicated, but milder agents, having a slighter destructive action, may be of use. *Theisen.*

On the Significance of the Nasal Sinuses in the Production of Bronchial Asthma.

W. N. Nikitin (*Archiv. fuer Laryngol. und Rhinol.,* Bd. 23, Heft 1) describes his treatment, which consists of hot water and steam baths for the purpose of furthering per-

spiration, together with the administration of internal remedies with the same object. Locally he has the nose washed daily with sea salt, in the proportion of a teaspoonful to a litre of water at body temperature. The irrigation is carried out morning and evening, and the litre of water must be used on each occasion. This is best done by a jug with a rubber tube and stop cock, and the nasal olive. The stream of water must also be directed into the pharynx of the patient, while he holds his head forward and says E. The sea salt owes some of its activity to the content of iodin. This treatment, independently of other remedies, is beneficial for the nasal chambers, and leads in the author's opinion at times to the cure of asthma. *Goodale.*

Bilateral Incision of the Mucous Membrane in the Submucous Resection of the Nasal Septum.

S. SREBRNY (*Archiv. fuer Laryngol. und Rhinol.*, Bd. 23, Heft 1) recommends an incision on each side of the nasal septum in this operation, and finds that perforations are not more frequent, while the time of the operation is decidedly shortened. He operates now in fifteen to forty minutes, according to the difficulty of the case. A bent incision from above down is made and prolonged on the nasal floor, it giving, in this manner, a larger space, and rendering less likely the tearing of the mucous membrane, after the introduction of the Killian speculum. After separation of the mucous membrane from both sides, the cartilage is cut through, the Killian speculum introduced, and as much of the cartilage and bone excised as necessary. After the operation the nose is tamponed on each side with especial care as to the disposition of the tampons, these being removed after three days. *Goodale.*

The Lymph Vessels of the Accessory Sinuses of the Nose.

L. GRUENWALD (*Archiv. fuer Laryngol. und Rhinol.*, Bd. 23, Heft 1) injected the head of a man, who had been killed immediately before by an accident, and examined the lymph vessels of the nose, with the following result:

On the posterior end of the hiatus semilunaris, the middle point of the injection is shown by a thick, slightly branching mass of color. From this point numerous branchlets stretch,

uniting with each other through fine lateral arms, as follows: Over the whole posterior recess of the middle meatus, together with the lower part of the lateral aspect of the middle turbinate covering it; the whole upper surface, both posteriorly and anteriorly, and also a certain portion of the median aspect of the lower turbinate; the upper and median aspect of the middle turbinate, corresponding to the injection phenomena on the lateral aspect. The margins of the bulla ethmoidalis, the processus uncinatus, and the agger nasi, together with the deeper lying lateral walls; the ethmoid sinuses when opened on removal of the median walls; a small communication which occurs in this specimen between a cavity in the bulla and the interior of the nose, is recognized by the penetration of the lymph vessels; from the hiatus semilunaris a small branch rises to the posterior wall of the frontal mucous membrane in the sphenoethmoidal recess. In the level of the choanae the branches unite concentrically towards the lower margin. After removal of the bulbus, together with the margins of the orbit from the median orbital wall, there is seen a blue injection in the upper third of the hiatus semilunaris. There is no injection in the periorbita itself. *Goodale.*

Lymphangiectatic Myxoma of the Nose.

Hajek and Polyak (*Archiv. fuer Laryngol. und Rhinol.*, Bd. 23, Heft 1) report a case of tumor of this type, arising from the base of the skull in the neighborhood of the lower margin of the sphenoid, infiltrating the body of the sphenoid, and the roof of the ethmoid, and extending later over the whole septum, the hard palate and the roof of the mouth, without metastasis, and terminating fatally by complicating tuberculosis. The authors have not been able to find a similar case in the last twenty years. *Goodale.*

Experiences With Intranasal Exposure of the Maxillary Sinuses.

Sturmann (*Archiv. fuer Laryngol. und Rhinol.*, Bd. 23, Heft 1) reports a series of his cases, in which he has operated by his method with satisfactory result. He uses local anesthesia; in the majority of cases cocain and adrenalin. After painting the canine fossa and the lower meatus with cocain, he injects from the mouth, under the periosteum of the facial

wall and below that of the lateral wall, two centimeters of his solution, next one centimeter of the solution through the inner surface of the ala nasi. The infiltration on both walls must reach far back; also a 2 per cent cocain solution may be sprayed into the maxillary sinus. If general anesthesia is used, the injection of cocain and adrenalin must be employed in addition, to diminish the otherwise excessive bleeding.

The operation is performed in the following way: An incision is made anteriorly in the nasal entrance, not more than half a centimeter from the free margin of the ala, by incising the nasal aspect of this with a bistoury, and carrying the cut parallel to the outer aspect, as far as the bone, which one finds about a centimeter from the aperture externally. The incision is prolonged upward and downward sufficiently, and at both ends turns toward the median line, in order to remain parallel to the margin of the nasal opening. This position of the incision is done in order that sufficient room can be obtained for the opening in front of the inferior turbinate, and also in order that a freer view may be obtained of the interior of the sinus. Laterally the cheek may be undermined as far as wished, but towards the median line the periosteum causes a little difficulty by its firm adhesion to the margin of the aperture. With the bent, blunt end of the author's elevator, it is possible to pass around the corner, and to lay free the bony nasal wall. This separation extends not only to the lower meatus, but also to the point of attachment of the lower turbinate of the maxillary bone, and of the mucous membrane covering this in front of the middle meatus. The author introduces a Fraenkel's nasal speculum, with blades five centimeters long, in such a way that the median blade lies between the maxillary bone and the mucous membrane of the lateral wall, including the anterior half of the lower turbinate, while the lateral blade lies between the maxillary bone and the cheek. Between the blades is the exposed pyriform aperture. The speculum remains in this position, so that no further retractors are required. As large a trephine as possible is placed directly upon the margin, and carried horizontally backward and outward. Since it runs between the two blades of the speculum it is not possible to wound the neighboring parts. Sometimes it happens that the trephine does not drill sufficiently in an outward direction,

and removes thus only a portion of the bony plate without opening the sinus. If this does not happen, one immediately enters the sinus. The opening is now enlarged, either with a trephine or bone forceps. It is necessary to take away as much from above as to afford a view of the roof of the cavity. This may be done without fear of deformity. On the nasal floor the bone is thickest, and its removal the most difficult. Nevertheless, it is of great importance that not the slightest wall divides the two cavities on the floor. The author removes as much of the facial wall as to permit a free view of its inner aspect. The extent of this depends on the difference in level between the anterior convex half, corresponding to the canine fossa and the posterior concave half. One must also remove as much of the convex nasal wall as to give a view of the angle between it and the posterior wall. The two walls are readily removed with the author's bone forceps. This permits now an inspection of the mucous membrane of the cavity, which is now irrigated and freed from any polypi present. Mucous membrane which is only thickened or edematous does not need to be curetted. Furthermore, it is perfectly possible in the subsequent treatment to remove any portions of the mucous membrane that may be necessary. The anterior half of the maxillary sinus is now seen to be separated from the nose by a partition which consists anteriorly of the skin of the nasal entrance, posteriorly of the mucous membrane of the lower and middle meatus, and carries unwounded the lower turbinate. This is now cut through from the upper end of the original incision in a horizontal direction, and then vertically in front of the lower turbinate as far as the nasal floor. In this way one obtains a flap with the base on the floor of the nose. Since it is anteriorly thick and usually too large, it must be thinned and cut correctly, in order not to form a disturbing growth on the nasal floor. The cavity is now filled with iodoform gauze, while the flap is fixed on the floor. The subsequent treatment consists in the reduction of swelling and relief of pain. The tampons are usually discontinued at the end of fourteen days.

Goodale.

III.—PHARYNX.

Local Anesthesia of the Tonsils.

M. RUPRECHT (*Archiv. fuer Laryngol. und Rhinol.*, Bd. 23, Heft 1) recommends local anesthesia of the tonsils by injection of cocain, and finds the amount of bleeding small, while the tendency of the patient to gag can be readily controlled with a certain care in the use of the tongue depressor. Even in the case of children this may be done, and is especially to be recommended for those with a lymphatic constitution and enlarged thymus. *Goodale.*

Functions of the Tonsils.

O. LEVENSTEIN (*Archiv. fuer Laryngol. und Rhinol.*, Bd. 23, Heft 1) reviews at length the various theories concerning the physiology of the tonsils, and considers that none of them can withstand criticism. No proof has been adduced that the tonsils fulfill a peculiar or important function of the organism. It must be regarded as undecided whether the tonsils represent an instance of atavism, and were originally useful to our remote ancestors. The physiologic disappearance of the adenoid in adult life, and the frequent atrophy of the faucial tonsils at an early age, must give us cause for thought in this connection, especially when we remember that man possesses also another adenoidlike organ, namely, the thymus, which atrophies in early life, and is correctly regarded as an atavistic organ. The author maintains that we have no proof for the existence of a function of the tonsils, but even then he adopts a conservative standpoint, and would regard our task as chiefly to consist in the removal of the possibilities of infection by rendering this organ more resistant through general or local measures. The laryngologist would not readily permit his tonsils to be excised, even if they did not appear as well armed against infection as they should be, since the process is by no means a simple one, and, furthermore, it must be remembered that adenoid tissue always undergoes regeneration, so that permanent absence of the lymphoid tissue cannot be anticipated. *Goodale.*

Tonsillectomy.

BLEGVAD (Proceedings of the Danish Oto-Laryngological Society, Feb. 16, 1910). It is extremely interesting to Ameri-

cans to note the gradual awakening of the European laryngologists to the necessity of the radical tonsil enucleation. This author reports sixteen cases before the Society in which he has had no serious after bleeding. The operation was evidently carried out with a snare without any attempt to dissect free the capsule. His indications for the operation are: 1. Repeated attacks of acute tonsillitis. 2. Repeated attacks of peritonsillar abscess. 3. In cases of tonsillitis lacunaris which give rise to well marked symptoms. 4. In those cases where the patient has suffered from some general disease directly attributed to the tonsillar infection. 5. In cases of adenitis colli where no other source of infection can be found. In the discussion, Schmiegelow remarked that he had carried out many thousand tonsillotomies with the Mackenzie tonsillotome, and was very well satisfied with his results. The partial resection (with the tonsil punch) he found particularly valuable in the case of small sunken diseased tonsils, and considers the radical operation as recommended by Blegvad as unnecessary and too complicated.

Mygind, who was this year a guest of the laryngological section of the A. M. A., added that he considered the complete tonsillectomy, in "small but diseased tonsils" (the remark in quotations was taken from the original report) has been a large and fruitful field.

Jörgen Möller considers the peritonsillar abscess as arising from the upper pole of the tonsil "where there is no fibrous capsule to be found".

Blegvad, in conclusion, said that the operation did not allow all the adenoid tissue that lay between the pillars to be removed, but that the upper pole could be completely removed.

Horn.

IV.—LARYNX.

Laryngocele.

JACOB GUGENHEIM (*Archiv. fuer Laryngol. und Rhinol.*, Bd. 23, Heft 1) reports a case in which a laryngeal sac was produced by long continued expiration in the playing of wind instruments. The disturbances were slight or transient. The condition represents an anatomic curiosity, and illustrates the genetic relation between man and ape. In the majority of apes the air sac represents a useless, obsolete appendix of the

vocal apparatus, the physiologic relation of which is in doubt, and we may therefore regard it here as representing an instance of reversion to the original type. We cannot consider that the air sac of man has been inherited from the apes, the probability being rather than both derive the organ from a common ancestor, antedating ape and man.

Goodale.

Amputation of the Tubercular Epiglottis.

SEIFERT (*Zeit. fuer Laryn., Rhin. und Grenzgebiete,* Bd. 3, Heft 2, 1910) reports cases up to date and adds five cases of his own. He used the Alexander guillotine, and his results were invariably good. Complete healing of the cut surface followed in ten to fourteen days, the dysphagia was always relieved, and the lung conditions always improved or cured.

Horn.

V.—MISCELLANEOUS.

Acute Thyroiditis.

W. LUBLINSKI (*Wiener medicinische Wochenschrift,* Oct. 15, 1910) criticises a statement made by Goldberger, in his article in No. 32 of this weekly, that no case of true iodid thyroiditis has been reported.

Lublinski, several years ago (*Deutsche med. Wochenschrift.* No. 8, 1906), published a case. A woman, aged 52 years, with syphilitic ulceration of the tonsils, was given, after the mercurial treatment, a 5 per cent solution of iodid of potash. After taking this for four days she had an acute thyroiditis. Her thyroid, before beginning the treatment, had been perfectly normal. After stopping the iodid the swelling of the thyroid disappeared within a week. In order to prove that the iodid had caused this, the author put the patient on the same treatment again, and the same thing happened.

Marothe, Sellei and Gondurow have reported similar cases.

Cases of acute thyroiditis are not as rare as Goldberger believes.

The author has reported cases following acute angina. Kocher has classified such cases as metastatic.

It is well known, however, that an inflammation of the thyroid gland occurs with different diseases, such as septic fever, typhoid and pneumonia. In most of these cases suppuration occurred, and in the pus the pathogenic organisms of

the primary disease were found, either alone or mixed with pus cocci.

The author has reported four cases of acute thyroiditis in women, following acute angina. This usually occurred on the fifth or sixth day after acute symptoms of the sore throat subsided, and was accompanied by another rise in temperature.

The author believes that the complication of angina with acute thyroiditis is analogous to the rheumatic conditions complicating sore throat.

In this class of cases the development of abscesses in the thyroid has not been observed. *Theisen.*

Concerning Leprosy.

GERBER (*Deutsche medicinische Wochenschrift,* No. 37, 1910), discussing the primary lesion, quotes Sticker, who believed that this was in the nasal mucous membrane. While this view has not been altogether accepted, there are many observers, particularly in the tropics, and, having a large amount of material at their command, who believe that Sticker's opinion is the correct one.

That leprosy of the face originates primarily in the nasal mucous membrane will appear rational to those who have studied the similar conditions in lupus. The view of Sticker and his supporters is not new, but was advanced 200 years ago by Wilhelm ten Rhyne, and even in the time of Aretaeus, leprosy was considered an inhalation disease.

The author at the present time has under observation in the Memeler leprosy home fifteen cases. These cases are being carefully studied by his first assistant, Dr. Cohn, and it was found that all of them show more or less severe evidences of the disease in the nose, pharynx and larynx.

In the author's work (Beiträge zum Kenntniss der Lepra der oberen Luftwege und der Verbreitung der Leprabacillen, *Archiv. f. Laryngol.,* Bd. 12, 1901), he gives the following figures: The nose is involved in 95.83 per cent of all cases, the pharynx in 73 per cent, and the larynx in 70.27 per cent.

His investigations would indicate that sooner or later almost all patients suffering with leprosy, develop lesions in the upper air passages, and furthermore, that a large percentage of patients with laryngeal leprosy die as a result of this complication.

The author comes to the following conclusions:

1. As a rule, bacilli are not found in the upper air passages, when healthy, of patients affected with leprosy.
2. This is also true of the upper air passages of healthy persons coming in contact with leprosy cases.
3. Lepra bacilli are present in large numbers in the diseased upper air passages of leprosy cases, and are most abundant in the nose.
4. Secretion lower down in the air passages is much freer of bacilli.
5. Bacilli can be found in fluid as well as dry secretion, after weeks and months, and as long as one year.
6. Bacilli are scattered around by sneezing, coughing and spitting.
7. Handkerchiefs are carriers of the bacilli, and many bacilli can be found in the water in which they are washed. All articles of apparel coming in contact with mucous secretion also carry the bacilli.
8. Gerber did not find bacilli in rooms of patients that were kept properly clean; neither in the beds nor on the floors or walls.
9. No bacilli were found in the tracheal secretion below tracheotomy wounds. *Theisen.*

Concerning Foreign Bodies in the Esophagus.

PERNICE (*Deutsche medicinische Wochenschrift,* September 15, 1910). According to Kaloyeropulos, foreign bodies in the esophagus, in about 40 per cent of the cases, are tooth plates. The question of extraction, whether by esophagotomy or gastrotomy, when such foreign bodies are impacted in the lower part of the esophagus, is important, and has not been positively determined.

In regard to the diagnosis, the author states that the fact that a foreign body could or could not be swallowed should not be considered. Even large foreign bodies may remain in the esophagus for a long time. Eitel has reported a case in which a tooth plate remained impacted in the esophagus for six and one-half years, and Bull mentions a case in which a similar foreign body was in the esophagus for a year and a half.

In every case in which the presence of a swallowed plate

is suspected, either an examination with a probe should be made, or by esophagoscopy, and the examination should be made as soon as possible. Of forty cases of foreign body in the esophagus, collected by Naumann, seven terminated fatally, four of the fatal cases being the result of impacted tooth plates. It is particularly important that sharp or angular foreign bodies should be removed as soon as possible. A radiograph is of the greatest assistance in locating the foreign body.

The prognosis depends upon the nature of the foreign body, the length of time it has been in the esophagus, and its location.

Foreign bodies present in the esophagus for a long time may cause swelling, pressure, ulceration, enlargement of the glands, infections or erosions of the blood vessels. Para-esophageal abscesses and mediastinitis have been reported. Neuhaus has reported a case of fatal hemorrhage through erosion of the carotid.

Immediately after the swallowing of a foreign body, attempts at removal, with or without the aid of esophagoscopy, may be made. Should such attempts fail, esophagotomy should be performed as soon as possible. If the foreign body is situated deep down in the esophagus, so that it cannot be felt with the finger through the esophagotomy wound, the method of procedure must be changed. In such cases Dobbertin recommends the opening of the esophagus through the posterior mediastinum. In the case of a tooth plate, a gastrotomy may have to be performed and the foreign body removed in this way. *Theisen.*

BOOK REVIEW.

"Die Krankheiten der Nase und des Nasenrachens."

By CARL ZARNIKO, Hamburg. Published by S. Karger, Berlin. Price, 19.60 marks.

The third edition of "Zarniko's Diseases of the Nose and Nasopharynx" is a book of over 700 pages. The other two editions were large and favorably received, and the present is but the logical outcome. It is the summation of 50 years of active practice in rhinologic work and will serve as an enduring monument to the intellectual activity of this great worker.

To select any given chapter as especially good would be slighting the rest of the book. One has a feeling that the conclusions are based on an unbiased study of the literature of the entire world and that any procedure recommended can be relied upon as the result of personal experience.

The thousands of references to original sources, which enables one to at once put oneself in possession of the complete literature, are of great importance. A full subject and author's index is also of great assistance. The subject matter is arranged in a very clear way, the less important matter being put in small print.

Every recent advance in rhinologic activity is discussed. Considerable space is given to modern methods of diagnosing the source of pus in accessory cavity disease, and the methods by means of suction, which have been so sadly neglected in America, have been given their proper weight.

The introductory chapters on anatomy, physiology and pathology, which were so favorably reviewed in the earlier editions, remain practically unchanged.

All in all, it is an encyclopedia of rhinologic information which will prove a classic for all time to come.

Horn.

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